FRANKLIN COUNTY WATER DISTRICT

EMERGENCY SPILLWAY

PRELIMINARY ENGINEERING REPORT

FINAL | January 2018

TBPE No. F-882

FRANKLIN COUNTY
WATER DISTRICT

FRANKLIN COUNTY WATER DISTRICT

EMERGENCY SPILLWAY

PRELIMINARY ENGINEERING REPORT

FINAL | January 2018

Digitally signed by Philip W. Bullock, Jr
Contact Info: Carollo Engineers, Inc.
Date: 2018.01.08 14:11:01-06'00'

STATE OF TEXAS
PHILIP W. BULLOCK JR.
114841
LICENSED
PROFESSIONAL ENGINEER

In Association With:

AquaStrategies

Contents

Appendices

Figures, Tables, Graphs, and Charts

Abbreviations

Arroyo	Arroyo Environmental
BC	Benefit Cost
BbB	Bernaldo
Carollo	Carollo Engineers, Inc.
CWA	Clean Water Act
CWSRF	Clean Water State Revolving Fund
CSSUD	Cypress Springs Special Utility District
Deere	Deere & Ault Consultants
EPA	Environmental Protection Agency
Excel	Microsoft Excel
FHWA	Federal Highway Administration
FMA	Flood Mitigation Assistance Grant
FPA	floodplain administrator
FCWD	Franklin County Water District
FrB	Freestone
H&H	Hydrology and Hydraulics
HEC-HMS	Hydrologic Engineering Center's Hydrologic Modeling System
KfC	Kirvin
LBS	Lake Bob Sandlin
LCS	Lake Cypress Springs
LoTP	Lake O' the Pines
LWCF	Land and Water Conservation Fund
msl	mean sea level
Na	Nahatche
NFIP	National Flood Insurance Program
NWI	National Wetland Inventory
NETMWD	North East Municipal Water District
OPCC	Opinion of Probable Construction Cost
PER	Preliminary Engineering Report
PDM	Pre-Disaster Mitigation Grants
RL	Repetitive Loss
REFA	Revised Existing Frequency Analysis
RAS	River Analysis System
TMs	Technical Memorandums
TCELCP	Texas Coastal and Estuarine Land Conservation Program
TCEQ	Texas Commission on Environmental Quality
TDPW	Texas Department of Parks and Wildlife
TDRA	Texas Department of Rural Affairs
GLO	Texas General Land Office

THC	Texas Historical Commission
TNRIS	Texas Natural Resources Information System
TPWD	Texas Parks and Wildlife Department
TWDB	Texas Water Development Board
DFund	Texas Water Development Fund
Ud	Udorthents
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WAM	Water Availability Modeling
WoC	Woodtell – fine sandy loam
WoE	Woodtell– loam-silty clay loam
WSE	water surface elevation

Preliminary Engineering Report

FRANKLIN COUNTRY WATER DISTRICT

1.0 INTRODUCTION

On December 27, 2015, the Lake Cypress Springs (LCS) watershed experienced a historic flooding event that caused lake waters to rise to record levels. The Water Surface Elevation (WSE) rose to a maximum of 383.92 feet above mean sea level (msl) or 5.92 feet above the conservation pool of the reservoir, set constant at 378.00 msl. Boats, houses, and boathouses experienced significant damage from the event costing many property owners, including the district, thousands of dollars in damages.

This flooding event, classified as a 350-year storm, resulted in the District's concern that the existing emergency spillway might not be located at the correct elevation. Although the emergency spillway (385.00 feet msl) was not engaged during the flooding event, anecdotal evidence suggested that it could be located higher in elevation than the original design specifies. As a result, the Franklin County Water District (FCWD), which owns and operates LCS, tasked Carollo Engineers, Inc., (Carollo) with investigating, analyzing, and submitting this Preliminary Engineering Report (PER) to determine if the current spillway elevation is located at the correct elevation, and if not, recommend alternatives to remedy the issue as necessary.

1.1 LCS and the Dam

LCS is a manmade lake located in Franklin County in northeast Texas. It consists of an approximately 75-square mile watershed and a dam. The dam, located on Big Cypress Creek, is a tributary of the Cypress Bayou.

The dam is a 5,230-feet long earth-fill embankment with a top crest at an elevation of 395.0 feet above msl, NGVD29 (msl). To control the release of flows, the dam was constructed with a morning glory-style service spillway located at the south end of the main dam embankment with a spillway elevation of 378.0 feet above msl. The service spillway has a fish screen from 378.0 msl to 384.0 msl, one foot below the emergency spillway elevation of 385.0 msl. The speed at which water flows over the spillway is determined by the water pressure in LCS and in Lake Bob Sandlin (LBS) downstream.

To the north of the dam is the emergency spillway, which is a generally flat graded area with a design elevation crest at 385.0 feet msl and a crest length of approximately 1,000 feet. The emergency spillway has never been engaged in the history of the reservoir. The only controlled releases of water are performed with a low-flow 18-inch valve structure that releases water into the bottom of the morning-glory type service spillway, which the District uses to meet obligations with the downstream water-right owners.

Figure 1 below shows a vicinity location of LCS. Figure 2 shows a schematic diagram of LCS's spillway, including the lake and conservation pool's elevations, the morning glory spillway, FCWD water customer intake elevations, and LBS. A detailed drainage area map can be found in Appendix A: Maps.

Figure 1: Vicinity Map

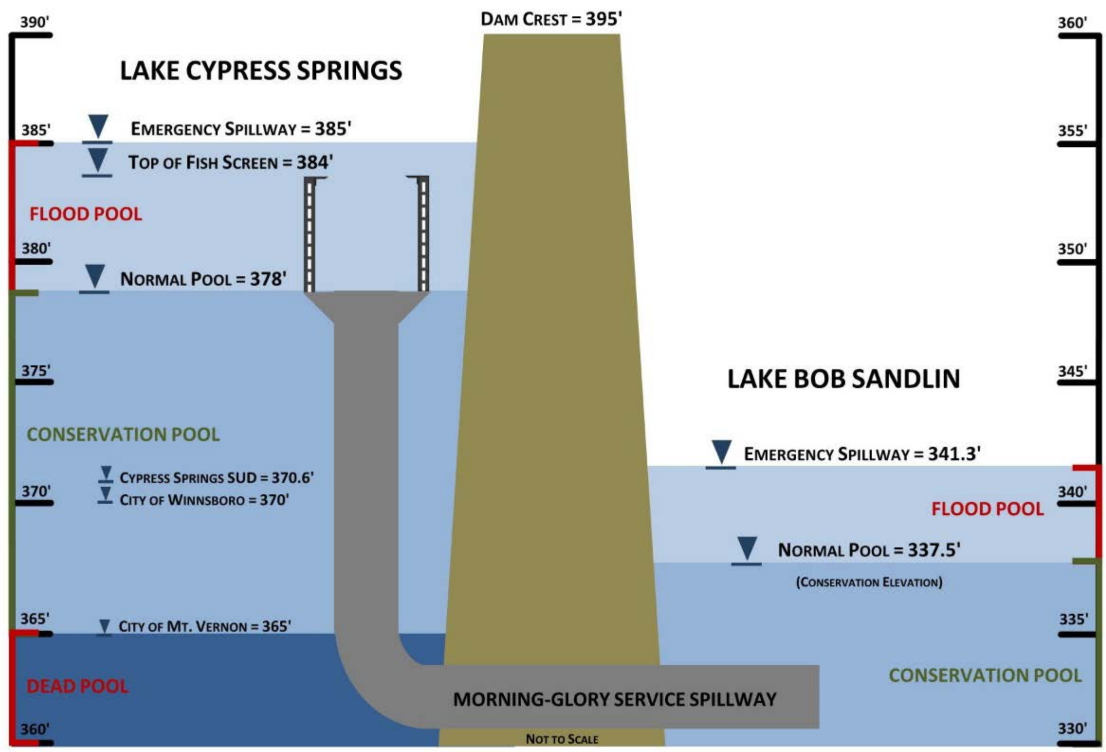


Figure 2: LCS Dam and Spillway Schematic

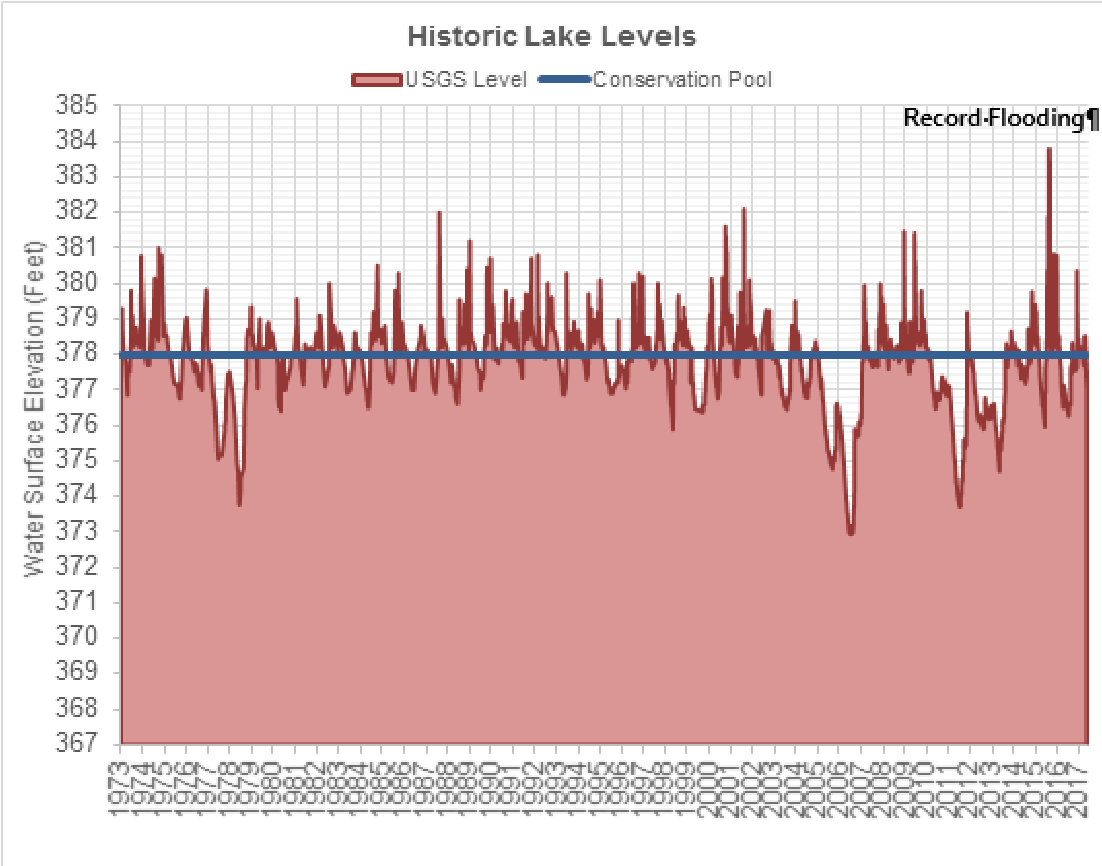
1.2 Historic Lake Levels and Previous Flood Events

Graph 3 below shows lake levels for LCS between 1973 and 2017. As the figure shows, LCS is not a constant level lake and has endured several droughts and floods where water levels rose or fell above or below the conservation pool elevation of 378 msl (shown as the blue line).

Significant droughts occurred in 1978, 2006, and 2011, when water levels dropped to 374, 373, and 374, feet respectively. In addition to the flooding event of 2015, significant floods occurred in 2001, and 2009, when waters rose to 382, and 381 feet respectively.

On December 27, 2015, the LCS watershed experienced a historic flooding event that caused lake waters to rise to record levels, as shown as "Record Flooding" in Graph 3 below. The WSE in LCS rose to a maximum of 383.92 feet above msl or 5.92 feet above the conservation pool of the reservoir set at 378.00 msl. As shown in Figure 4 below, and as presented in a Public Stakeholder Meeting for Flood Relief Alternatives (April 5th 2016), the reservoir experienced an approximated 350-year storm event.

In response to this storm event, the FCWD took steps to understand the hydrology of the storm and how the reservoir responded hydraulically. Through various analysis and a first PER for Flood Relief Alternatives, Carollo provided the district with information that was utilized in this report. Additionally, Carollo completed various public forums to inform the public, gather information, and take suggestions. Suggestions made in these public forums brought to light the possibility of an issue with the emergency spillway discussed in future sections of this report.



Graph 3: Historic Lake Levels

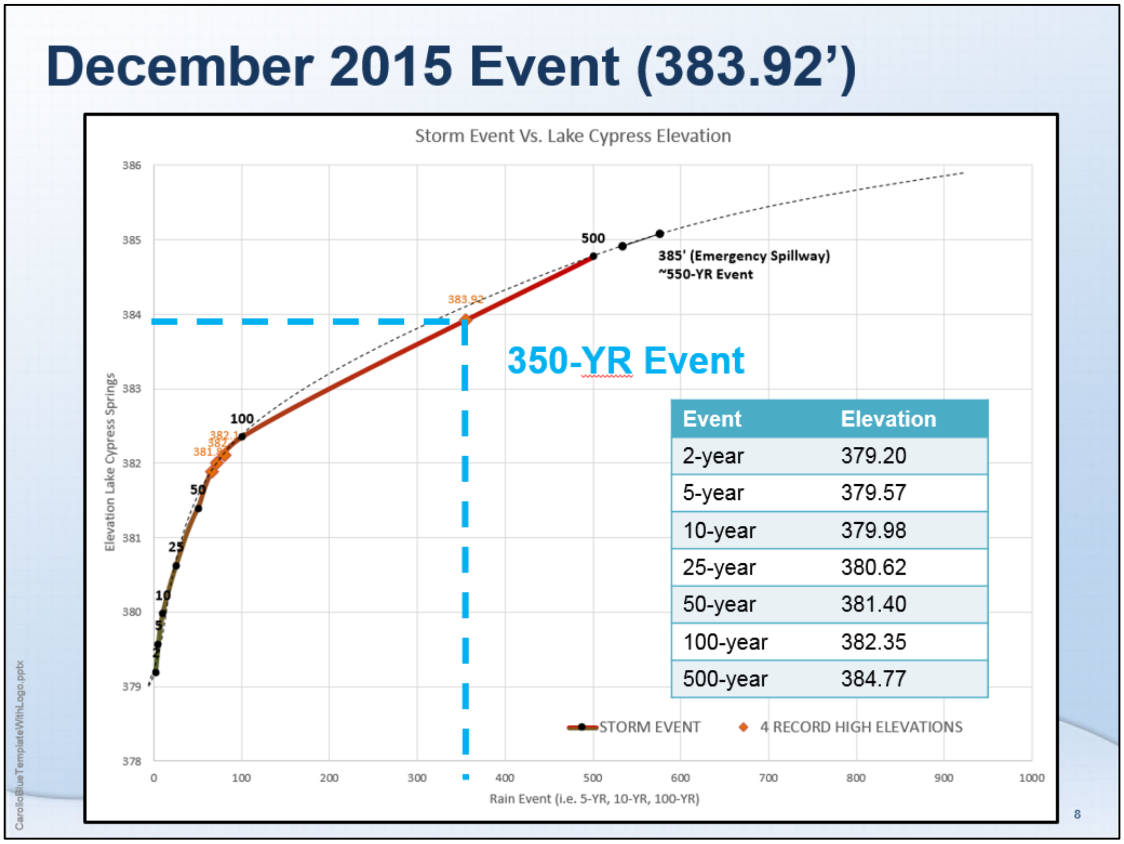


Figure 4: Slide from Public Stakeholder Meeting from Flood Relief Alternatives

1.3 Purpose of this Report

During presentations to the public in the PER for Flood Relief Alternatives, the District heard from concerned customers that the Emergency Spillway appeared to be higher in elevation than the roadway that crossed it (FM 3122). This was concerning because it was the District's understanding that FM 3122 was, more-or-less, the governing elevation for the Spillway's engagement. The District had leased the land to hay farmers from July of 1983 (approximately 34 years) and it was thought that this farming activity slowly raised the Emergency Spillway's elevation.

This report identifies, broadly describes, hydraulically models, and technically evaluates means of rehabilitating the Emergency Spillway.

The District hired Carollo to complete this analysis to:

- Determine if the Emergency Spillway on LCS contained fill deposits in areas that differed to the design
- Determine the quantity of fill (in cubic yards) that was deposited on the spillway
- Determine the hydraulic impacts of the existing condition spillway
- Determine the hydraulic impact of returning the spillway to its 1966 design
- Determine alternatives to return the spillway's flood conveyance ability, but provide cost-savings benefits.

The overall purpose of this PER is to explore the FCWD's options for the restoration of the Emergency Spillway back to the original design completed in 1966. To do this, Carollo studied the existing emergency spillway and compared the results to the hydraulic feasibility of the alternatives proposed. Flood damage reduction benefits are estimated in this report and used to identify the feasibility for possible implementation. In doing so, Carollo developed a curve for damages around the reservoir, the District's risks, and the costs associated with each of the alternatives evaluated.

The results of this PER should serve as a roadmap to summarize the feasibility of alternatives that have high potential to have long-term hydraulic effectiveness. The overall decision to implement a specific proposed alternative and the process to determine how to fund an emergency spillway project is solely left up to the FCWD, as Carollo was not authorized to recommend a specific alternative for selection.

For this PER, approximations and professional judgment are incorporated into the development and assessment of decisions. Proposed alternatives are described and evaluated only at a planning level, with the full intention that a design process will be required before any one project or portion of any one project developed in this PER can actually be implemented.

2.0 PRELIMINARY EVALUATION

2.1 Purpose of Emergency Spillway

The LCS Emergency Spillway is located north of the dam. The spillway, acting as a large "water runway," conveys water down the 1,000 ft wide excavated portion of the property owned by the FCWD, over FM3122, and into Andy's Creek. Andy's Creek is used to convey the water to LBS downstream of LCS. Based on the configuration of the emergency spillway Carollo suspects that surplus fill from the Emergency Spillway was excavated for use on the dam, although this was unconfirmed.

The Emergency Spillway was originally thought to be designed with FM 3122 acting as the highest elevation of 385.0 msl, which would make the roadway the governing hydraulic characteristic of the spillway (i.e. the weir). Further discoveries from the investigation of the design drawings actually show that FM 3122 was not designed to be perfectly perpendicular to the spillway, and thus is not the highest point along the entire cross section. Areas north-east and south-west of the roadway gradually slant to Andy's Creek and the lake respectively. An aerial of the emergency spillway is shown below in Figure 5.

The as-built drawings for the emergency spillway were extracted from the full dam design set and can be found in Appendix A: Maps.

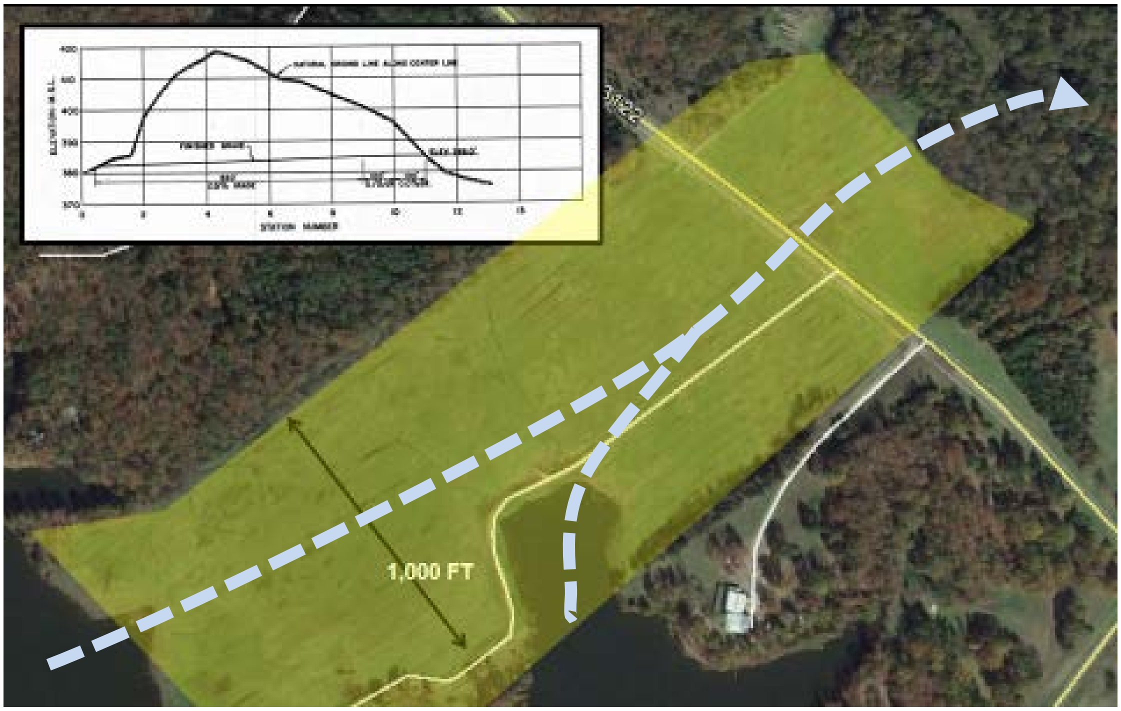


Figure 5: LCS Emergency Spillway Diagram

3.0 DATA GATHERING

A significant amount of data was gathered for this PER. This data was used in the modeling phase, the evaluation of the BC-ratio (further explained below), and the cost estimate. This section outlines the various data that was gathered and their sources.

3.1 FCWD Data

The FCWD provided Carollo sufficient archival information used in this evaluation. This data generally included:

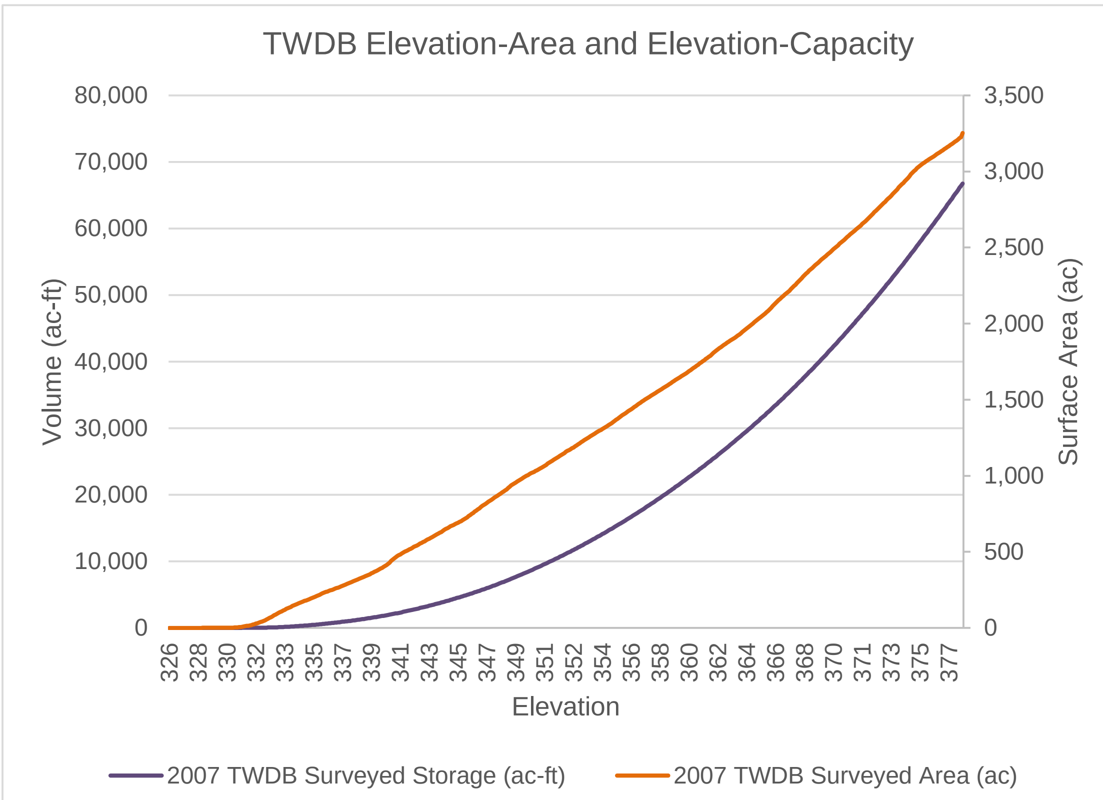
- 1966 Design drawings for the LCS dam, emergency spillway, and morning glory spillway
- Survey data from 2006 completed on the emergency spillway
- Historic lake elevation information
- Landowner parcel information
- Dam breech analysis models (HEC-RAS and HEC-HMS) discussed in subsequent sections of this report
- Previous hydraulic analysis completed for the morning glory spillway and low-flow service outlet
- Design files for the morning glory spillway fish screen
- Water right information, certificate of adjudications, TCEQ reported uses, customer information, etc.
- Current FCWD rules and regulations
- Franklin County Dam Breech Analysis (April 2006)
- Franklin County Dam Operations and Maintenance Manual (FNI July 2011)

3.2 3rd Party Data

3.2.1 *TWDB Lake Survey*

In July 2007, the Texas Water Development Board (TWDB) completed the *Volumetric and Sedimentation Survey of LCS*. The results of this volumetric survey showed that LCS has a total reservoir capacity of 66,756 acre-feet and encompasses 3,252 surface acres at conservation pool elevation (378.0 feet above msl, NGVD29). The results also showed that LCS has accumulated 3,807 acre-feet of sediment since impoundment in 1970. Appendix B: Volumetric Survey contains the full report.

The report's elevation-capacity and elevation-area curves formed the foundation for the LCS models developed and described in this report. Graph 6 below shows the lake's volume relative to its elevation (left- y axis) and the lake's surface area relative to its elevation (right- y axis).



Graph 6: TWDB Elevation-Area and Elevation-Capacity Curves

3.2.2 *USGS Data*

The United States Geologic Survey (USGS) provides surface-water (lake elevation) and atmospheric (rainfall) gauge data used by Carollo in this evaluation. Additionally, the FCWD keeps archived records of lake elevation data, partially supplemented by USGS gauge data (when available within the period of record). Figure 7 below shows the local USGS gauges. Use of USGS gauge data is documented where necessary in this report.

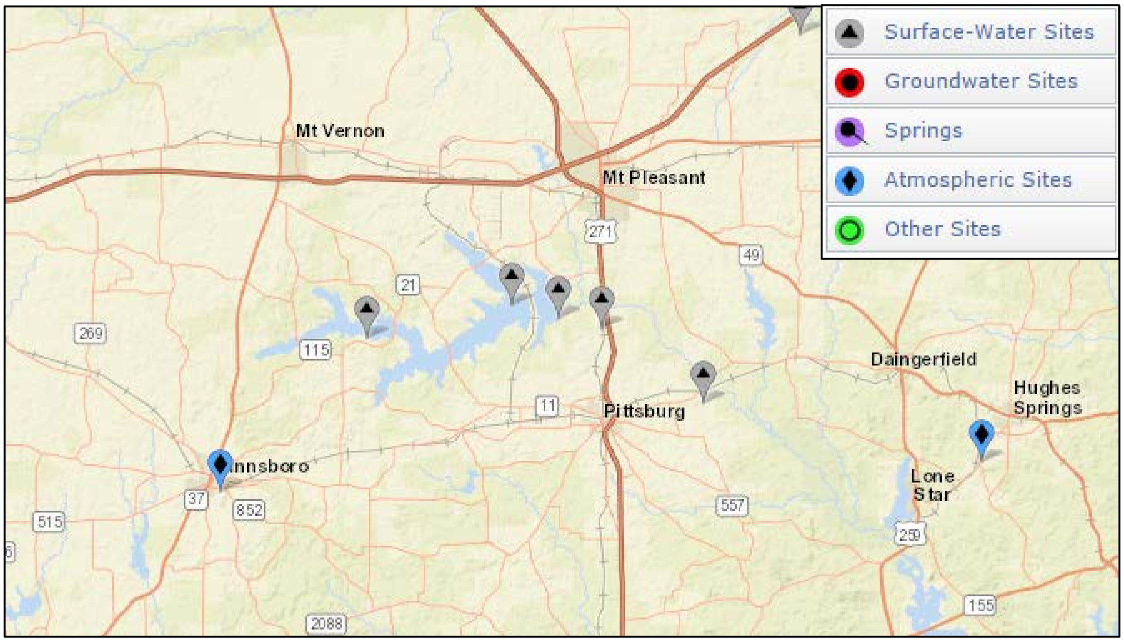


Figure 7: Local USGS Gauge Locations

3.2.3 LiDAR Data

LiDAR data was gathered from the Texas Natural Resources Information System (TNRIS) to acquire elevation information for areas around the emergency spillway outside the boundary of the survey information. This LiDAR data was primarily used in the establishment of the surfaces used in the hydraulic models in areas outside the elevation survey limits.

3.3 Existing Dam Breach Models

The Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) is a software used by engineers to model water systems similar to the District LCS system, and provides interactive simulations for the complete hydrologic processes of dendritic watershed systems. The HEC also provides engineers with a River Analysis System (RAS) model that typically works concurrently with HMS to complete detailed hydraulic simulations of the system.

The FCWD provided Carollo with a set of HEC-HMS models and HEC-RAS models previously completed by another consultant for requirements from TCEQ on their dam breach analysis.

3.4 2006 Survey

During the public forum meetings for the Flood Relief Alternatives PER, lakeside residents made the District aware that the emergency spillway, in part or in full, might have changed in elevation from the time it was constructed. Although the emergency spillway was not engaged in the 350-yr December 2015 event, elevation changes to the spillway contradicting the design, particularly with increased ground surface elevation, could leave LCS vulnerable in events that would engage the spillway. In the past, the spillway has been used for some agricultural purposes, which could explain the altered topography of the spillway over time. Anecdotal evidence of Carollo staff visiting the site does suggest that the ground south of the roadway appears to be higher in elevation than the roadway itself, a contradiction to the design.

An on-the-ground survey was conducted by Harcrow Surveying, LLC in 2006 and further inspection of that survey confirmed some areas within the spillway are higher than SH3122.

3.5 Access Road and Adjacent Leased Parcel

During the investigation process, it was discovered that the District has leased property adjacent to the emergency spillway on the south side (see Figure 8 below). This leased property itself is not located within the emergency spillway corridor, however a dirt road used to access the property is currently used that is located within the spillway. In the future, as a development for this property is planned and permitted with the District, it will be imperative to relocate the access roadway to a new location. As shown below, most asphalt-constructed roadways are crowned to allow for proper drainage. The crowing of a paved road in the middle of the emergency spillway could have a hydraulic effect and should be evaluated.

Although its current location and condition need not be moved, the construction of an elevated asphalt roadway must be considered from a hydraulic perspective. Two possible relocation scenarios are shown below in Figure 8, but each should be evaluated hydraulically by the District once planned and further designed.

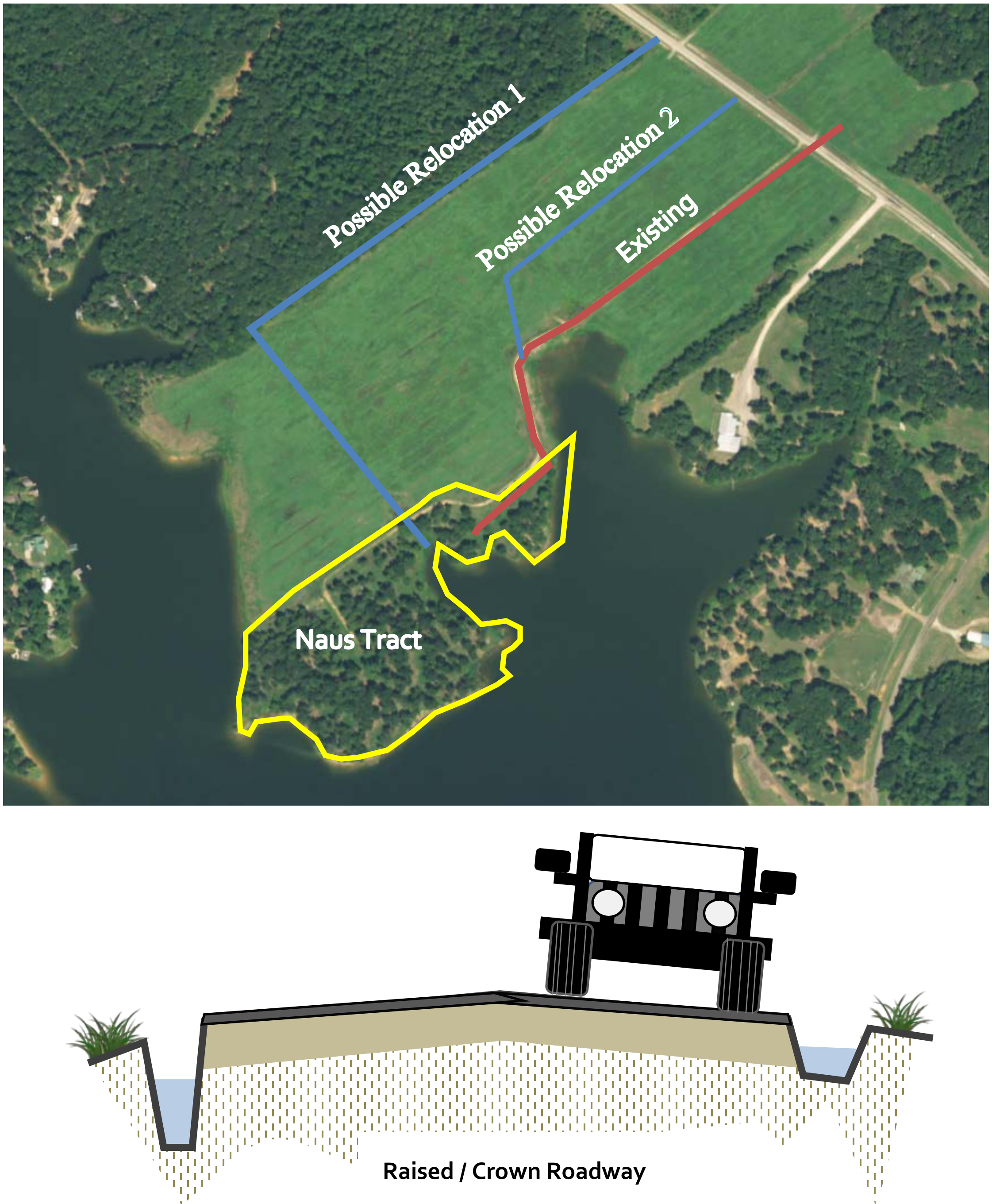


Figure 8: LCS Emergency Spillway Cross Section

A detailed map of this particular parcel and the lease of property can be found in Appendix A: Maps.

4.0 ALTERNATIVES IDENTIFICATION

In an effort to evaluate the Emergency Spillway from a hydraulic context, a series of alternatives were identified to allow for the comparison of different model surfaces. Carollo identified 3 primary alternatives, with Alternative 3 having two secondary alternatives (3A and 3B).

4.1 Alternative No. 1: Existing Conditions/ No Action

As a baseline for the comparison of alternatives, an existing condition / no action Alternative No. 1 was evaluated. This alternative, in addition to providing baseline control, will showcase the current response of the reservoir to an extreme flooding event and outline, for the District, the damages that would occur around the reservoir if an extreme event occurred today. As labeled a no-action alternative, the District can utilize this alternative as the justification for taking no-action to modify the Emergency Spillway.

4.2 Alternative No. 2: Return Emergency Spillway to Design

This proposed Alternative No. 2 alternative would be to return the elevation of the Emergency Spillway back to the original design specifications. The original design of the emergency spillway is shown in Figure 9 below and available in Appendix A: Maps. This design is dated 1966 and, according to the District, represents the best as-built information that is available. Returning the Emergency Spillway to its original design would require removal of the excess fill and modifications (lowering in most areas) of FM 3122.

To date, the elevation of the spillway has risen by a volume of roughly 105 thousand cubic yards dispersed throughout the corridor. The elevation change ranges from approximately 0.5 feet to 2 feet.

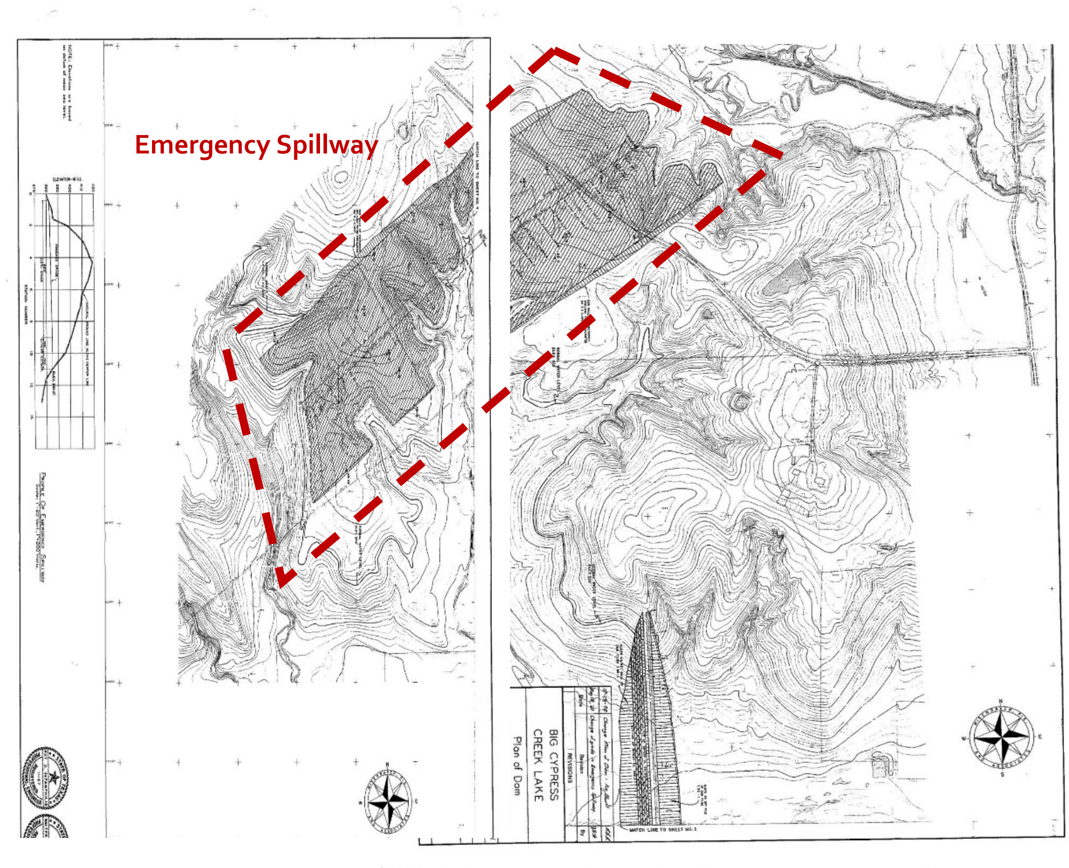


Figure 9: LCS Emergency Spillway Original 1966 Design

4.2.1 Survey Compared to 1966 Design

In looking at Alternative No. 2, Carollo was retained to determine if the emergency spillway currently exists as the design intended. Carollo utilized a survey that was completed in 2006 and compared it to the original dam plans completed in 1966 to determine if there has been additional fill accumulated on the spillway. As shown in Figure 10 below, the existing emergency spillway did exhibit, in most areas, an excess of fill above the designed ground elevation. The accumulation of fill ranges from approximately 0.5 feet near the center of the spillway to 2 feet in the outer locations. Additionally, the cross section, situated down the center of the emergency spillway, below in Graph 11, also shows the accumulation of fill, with the red line showing the existing ground surface elevation, and the blue line showing the designed surface.

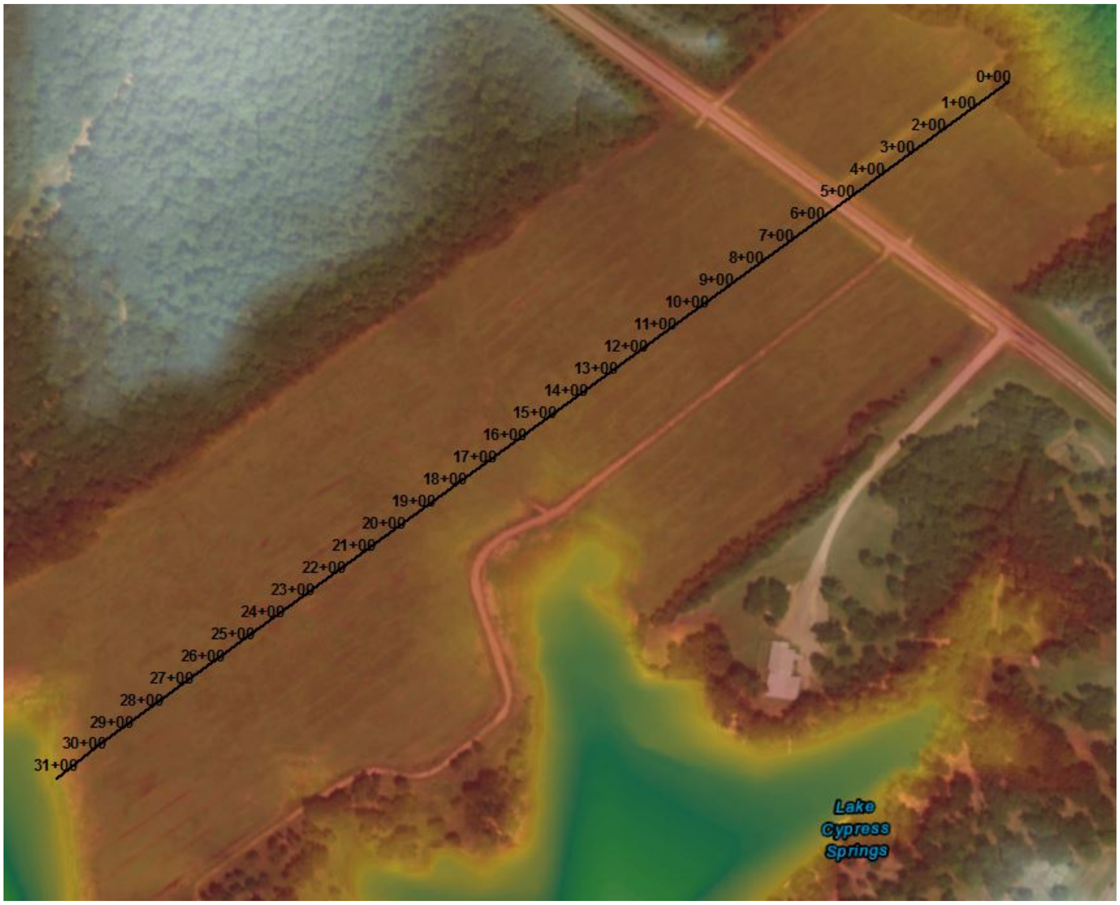
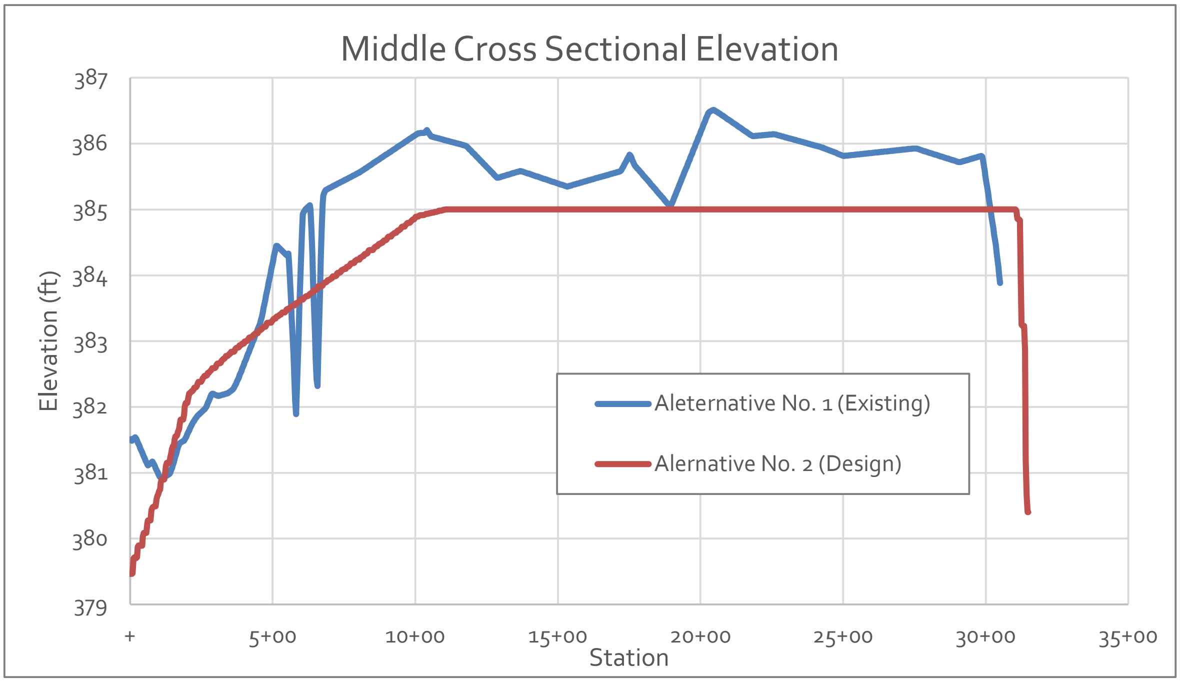


Figure 10: LCS Emergency Spillway Elevation Comparison



Graph 11: LCS Emergency Spillway Profile LIne

4.2.2 FM 3122 Roadway Comparison

In addition to having excess fill material deposited throughout the Emergency Spillway, it was also discovered that the FM 3122 alignment differs in elevation from the 1966 design. As the station-elevation graph below showcases, FM 3122 appears to have been constructed at approximately 1+ feet higher in elevation than the 1966 design intended. It is unknown if road overlays, improvements, or rehabilitation is to blame for this difference. It is possible that the asphalt roadway was constructed after the spillway was built, thus adding a layer of compactable select-fill and inches of asphalt.

Figure 12 below shows a stationed cross-section across the roadway at the dam, and Graph 13 shows the difference is elevations.

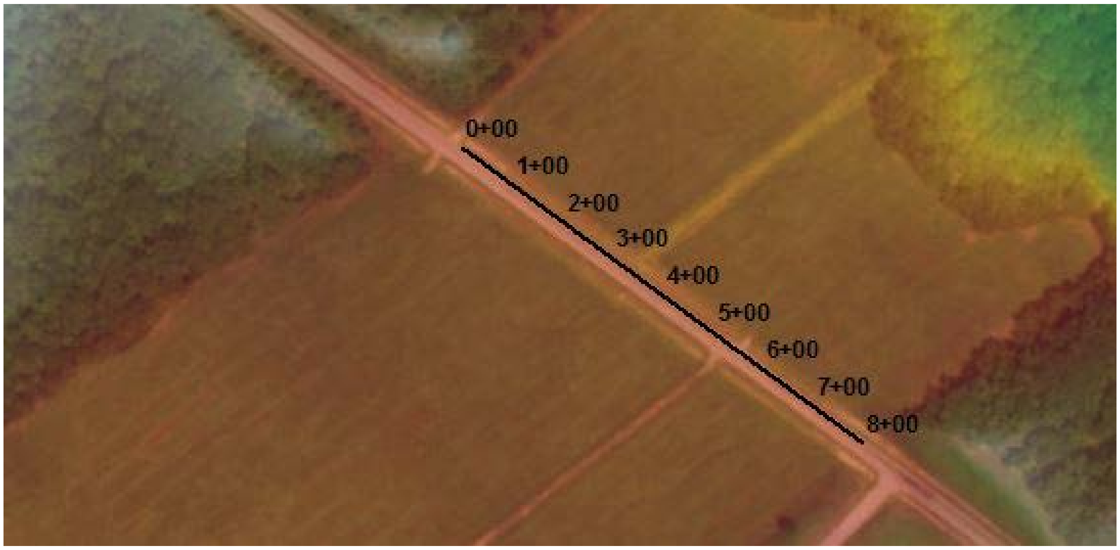
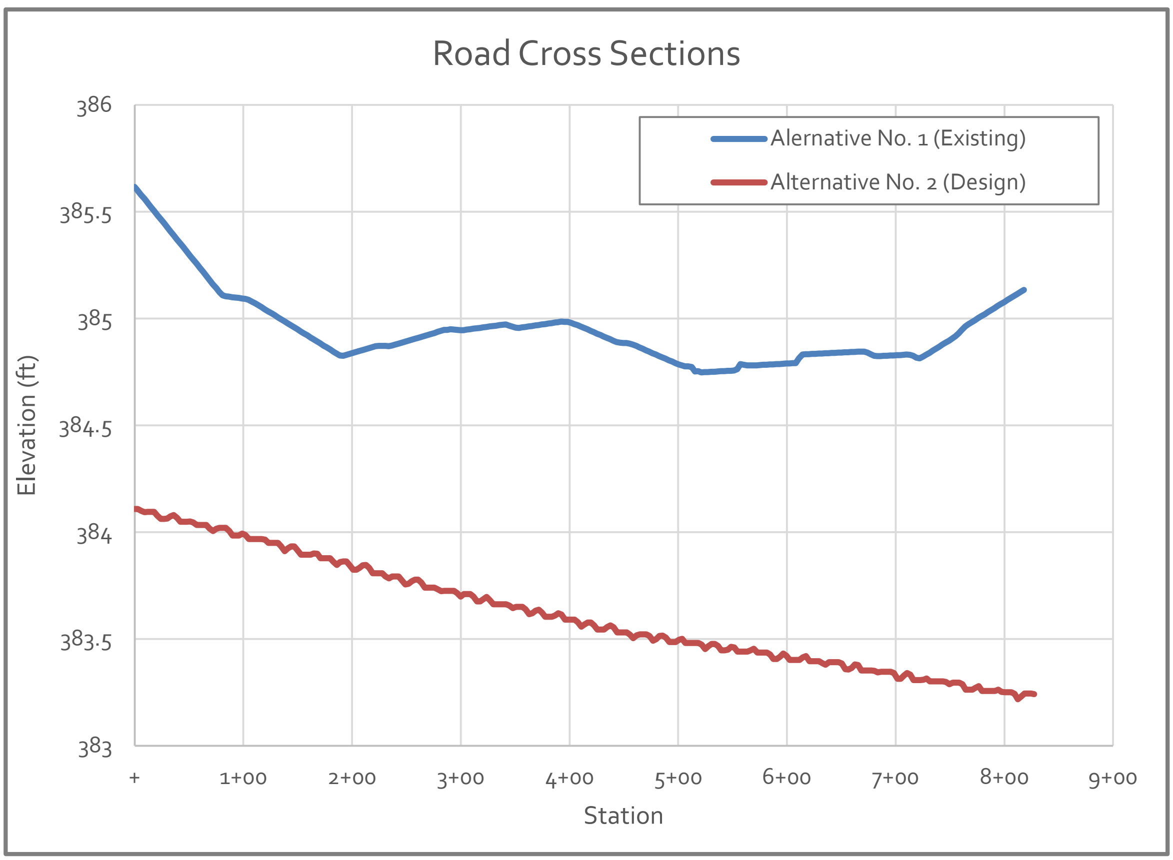


Figure 12: FM 3122 and stations across section



Graph 13: Road Profiles

4.3 Alternatives Nos. 3A and 3B: Optimized Emergency Spillway Restoration

Two additional alternatives (3A and 3B) were identified as possible solutions to restoration. These alternatives were evaluated for the purpose of cost-savings to the District without sacrificing hydraulic characteristics of the Emergency Spillway. In general, both of these alternatives involves the relocation of the fill material to different locations within the Emergency Spillway corridor on-site. In doing this, the excess fill will be dispersed on-site instead of needing to be hauled off-site, thus saving the district additional costs in the restoration.

4.3.1 Alternative No. 3A: Optimized Restoration Including FM3122 Alterations

Alternative No. 3A involves the relocation of excess fill material into two different less-hydraulically critical areas, raising the elevation in these areas by approximately 2 feet. The areas remain low-profile and flat in elevation, and are still capable of conveying water over the top in larger storm events.

One note, Alternative No. 3A does involve the modification of the FM 3122. As discussed earlier in this report, FM 3122 appears to be constructed at a higher elevation in most areas than the original design intended. This alternative includes modifications to FM 3122.

4.3.2 Alternative No. 3B: Optimized Restoration Excluding FM3122 Alterations

The second Alternative No. 3B is similar to No. 3A, but would involve the piling of dirt into one area on the spillway far from any water flow, which would raise the elevation by 6 feet. This again is a cost saving measure that can be utilized to ensure the dirt is dispersed instead of hauled away.

An important difference is also that Alternative No. 3B does *not* involve the modification of FM 3122 (a cost-saving measure), which will showcase to the district the hydraulic effects of removing excess dirt from the emergency spillway but leaving the roadway as-is.

5.0 EMERGENCY SPILLWAY MODELING

5.1 Hydrology vs. Hydraulics

The study of water is classified into two primary categories of hydrology and hydraulics, which both include the study of water properties and behaviors. Because of this, it is often difficult to understand the difference between the two:

- Hydrologic analyses are performed to quantify the volumetric flow rate (typically measured in cubic feet per second) of water draining from a watershed over time. The amount of water that flows from a given watershed depends heavily on its characteristics (e.g., size, land use, land cover, steepness, etc.) and the abundance of water (e.g., the intensity and duration of a precipitation event, or releases from an upstream dam).
- Hydraulic analyses are performed to determine the depth of flow, flow velocity, and forces from flowing water on a hydraulic structure. These studies are necessary components in the design and analysis of structures used to convey water.

In this PER analysis, Carollo performed only hydraulic evaluations as described in this modeling section. Hydrology information utilized in the hydraulic analysis was taken from previous studies, as discussed in the data gathering section of this report.

5.2 2D vs. 1D Hydraulic Modeling

Hydraulic modeling in two dimensions (2D) is an advanced modeling technique when compared to one-dimensional (1D) modeling. 2D modeling allows for prediction of both longitudinal and lateral differences (i.e. 2D) in velocity, water surface elevations, shear stress and depth. One dimensional modeling is widely used for determining longitudinal water surface profiles and laterally-averaged velocity at each cross section, but 1D modeling is less effective in considering localized variations. For this evaluation, a 2D model was chosen as the best method for understanding how the variable reservoir will react to a serious flooding event.

5.3 Software Used

Hydrologic Engineering Center's (HEC) River Analysis System (HEC-RAS) modeling software version 5.0 was used to evaluate the feasibility of each proposed Emergency Spillway renovation alternatives. HEC-RAS 5.0 is a program that is capable of 1D and 2D hydraulic analysis, lake storage volumes, steady-state and dynamic simulations, and is a tool used by engineers and floodplain managers to analyze drainage patterns in natural and constructed environments.

5.4 Assumptions within the Model Surfaces

A critical component of a 2D hydraulic model is the geometric terrain surface. Each surface, one developed for each Alternative (1, 2, 3B, and 3B), allow the model to determine how the lake outflow will interact with the terrain of the Emergency Spillway.

5.4.1 Mesh & 2D Surface Roughness

The 2D flow area uses a three dimensional mesh to discretize each terrain surface. The mesh is used in HEC-RAS to complete 2D finite volume hydrodynamic computations. The nominal mesh size is 50 feet by 50 feet for outlying areas. In the emergency spillway region, where velocities are higher and increased resolution of small-scale topographic structures was desired, a smaller mesh size of 12 feet by 12 feet was used. Break lines were used in HEC-RAS to set mesh size and to discretize roadways, ditches and other topographic features within the emergency spillway area. Increased resolution of the terrain allows for increased accuracy of velocity and depth results in regions of potential scour. Figure 14 shows a portion of the mesh on the existing emergency spillway.

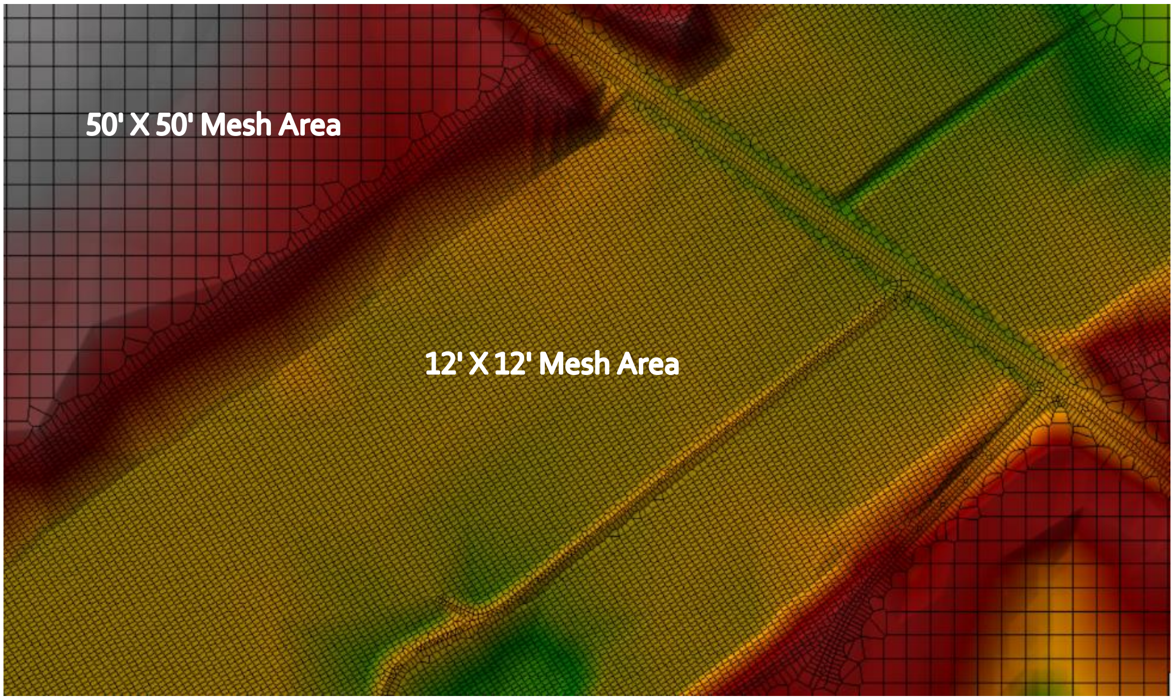


Figure 14: HEC-RAS 50x50 and 12x12 Mesh over a Portion of the Emergency Spillway and FM 3122

Friction loss in the 2D region is modeled using spatially distributed Manning's roughness values (Figure 15 blow). The emergency spillway region has a Manning's roughness value of 0.035, a normal value for pasture with no brush and high grass, or mature cultivated row crops (Chow, 1959). For regions not identified (e.g. lake region) the default value was set to 0.025. The region southeast of the emergency spillway that does not have a defined roughness is not inundated during HEC-RAS modeling.

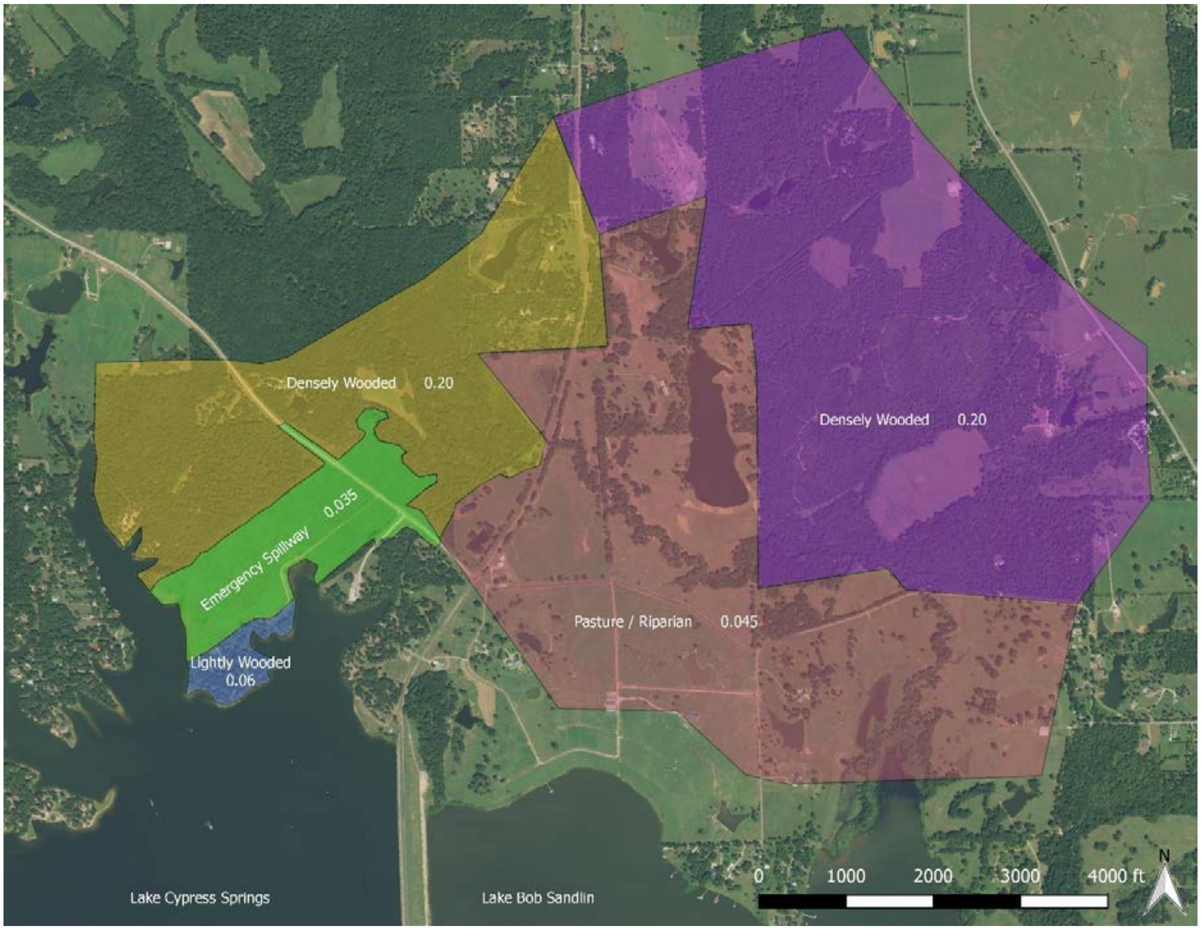


Figure 15: Manning's roughness coefficient regions for the 2D flow area. The leased land region is classified as Lightly Wooded 0.06.

5.5 Alternatives Surface Creation

5.5.1 Alternative No.1 (Existing): Surface Creation

The Alternative No. 1 (Existing) surface was combined from three sources:

- The 2006 Emergency Spillway survey from Harcrow that was provided by the FCWD.
- USGS 2011 National Elevation Dataset (NED).
- Texas Water Development Board (TWDB) Lake Cypress Springs contour lines.

When overlap occurred (e.g. topographic survey over the NED) the higher resolution dataset was used. Portions of the NED near Lake Cypress Springs had to be manually adjusted because of inconsistent elevations compared to the TWDB Lake Cypress Springs contour lines and topographic survey data. These inconsistencies were essentially holes in USGS NED data near the lake and their elevations were filled to 380 feet. Raw topographic survey data were used along with break lines to properly represent the roads passing through the emergency spillway. The final terrain is a regular grid that has a 3 foot resolution. The finalized surface for Alternative No. 1 (Existing) is shown below in Figure 16 and Figure 17.

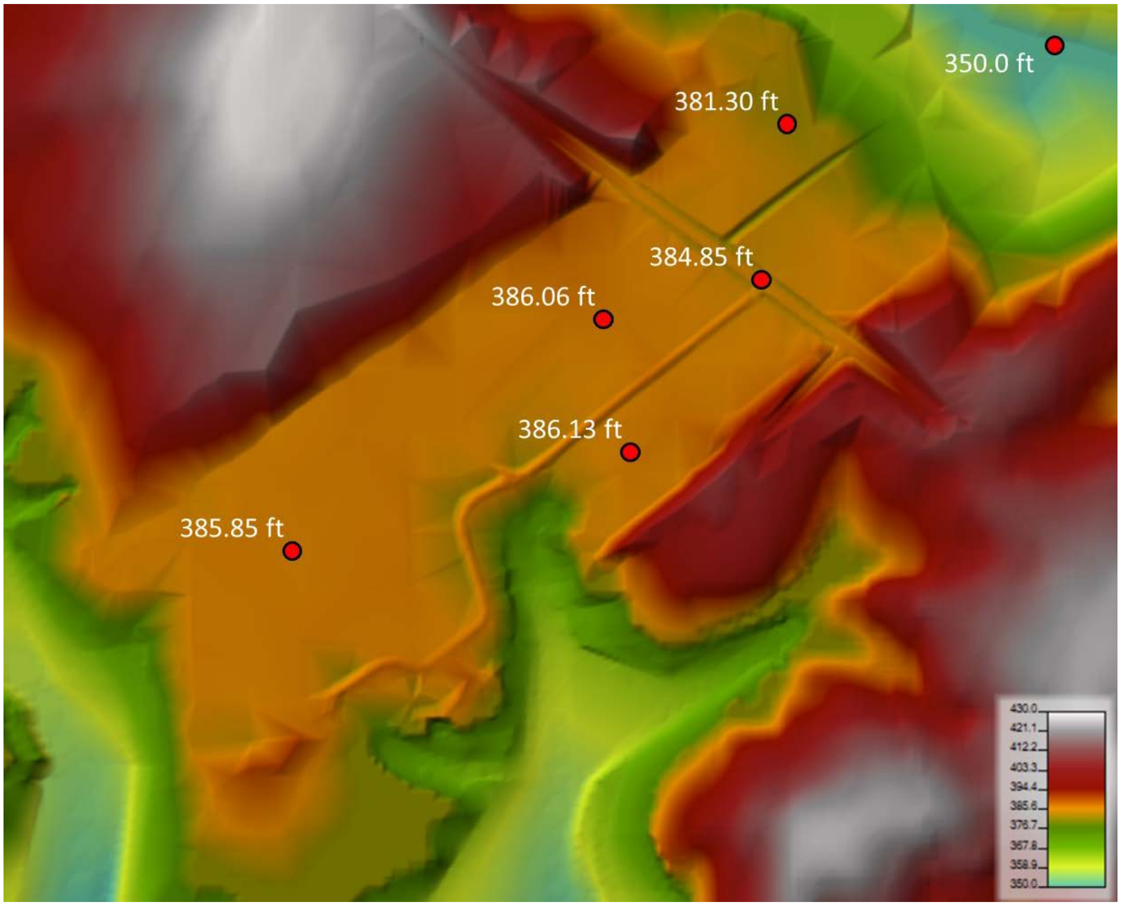


Figure 16: Finalized Alternative No. 1 (Existing) Surface with Spot Elevations

5.5.2 Alternative No. 2 (Design): Surface Creation

From the Alternative No. 1 Existing Conditions Surface, the Alternative No. 2 original design surface was created. To create this surface, the Alt. 1 (existing) surface was first overlaid with the final Emergency Spillway design from 1966. This overlay required approximation, as no benchmark information or lat/long was discovered on the design files. Carollo matched up the FM 3122 corridor and utilized other locatable indicators (such as the road) to match up the design file with the existing surface. The 1966 design overlaid on the Alt. 1 (Existing) surface is shown below in Figure 17.

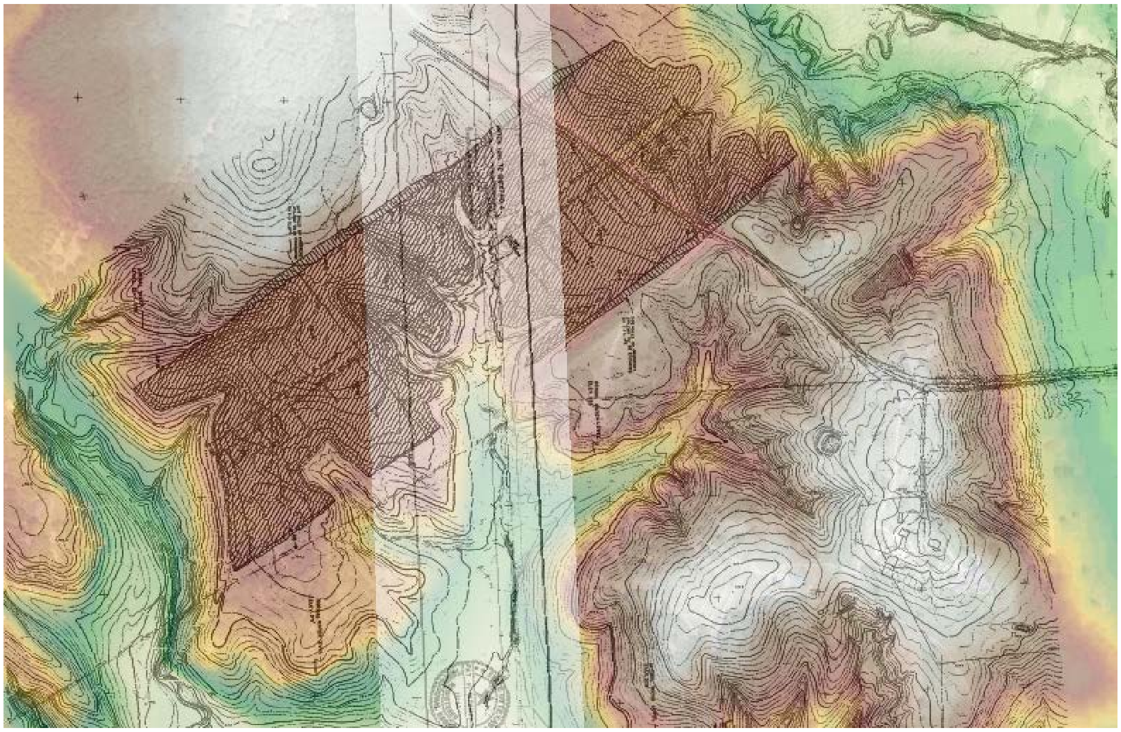


Figure 17: Overlay of Original 1966 Design Surface onto Alternative No. 1 (Existing) Surface

As shown below in Figure 18, a series of elevation points (blue) containing the initial design specifications were then added onto the Emergency Spillway. These points were chosen along each 100-foot cross section of the design, where elevations were readable. The elevations of the points corresponding to the stations in the design were set to match their originally intended design elevations from the 1966 plans. A secondary set of points was then created (pink) to tie the design surface elevations to the surrounding existing elevations. A new raster digital elevation file was generated using the manually assigned elevations and the elevations from the existing surface of the surrounding points.

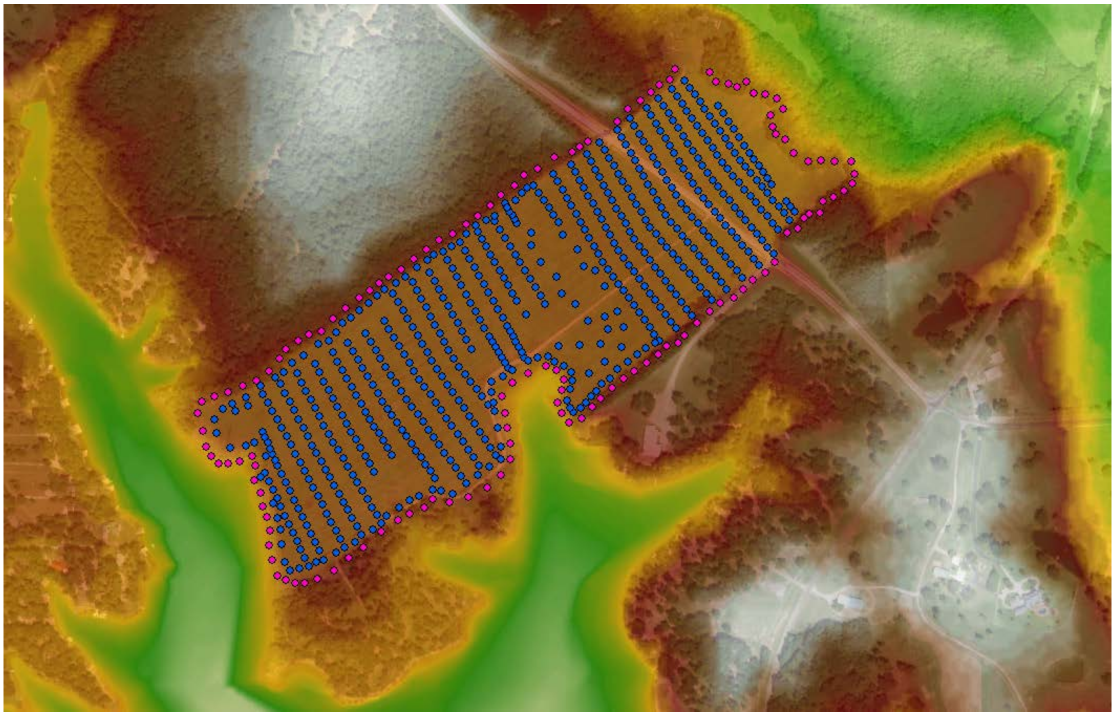


Figure 18: Development of Alternative No. 2 Surface

Figure 19 below shows the surface elevations of the Alternative No. 2 Surface as well as an illustration representing the need to move the fill off site.

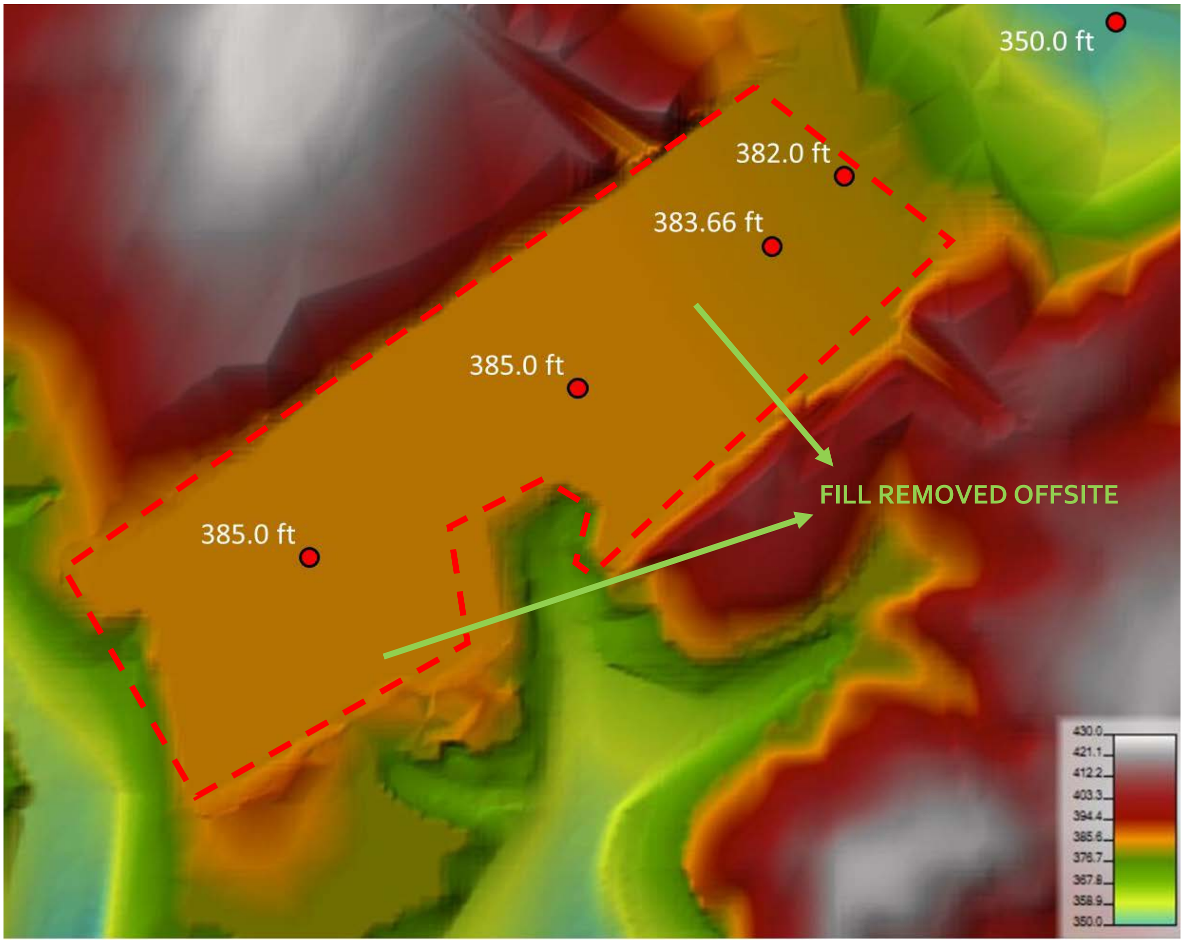


Figure 19: Alternative No. 2 (Design): Original design surface HEC-RAS terrain

As shown below in Figure 20, the finalized raster surface was generated to represent the 1966 design surface of the Emergency Spillway and is titled Alternative No. 2 in the hydraulic model.

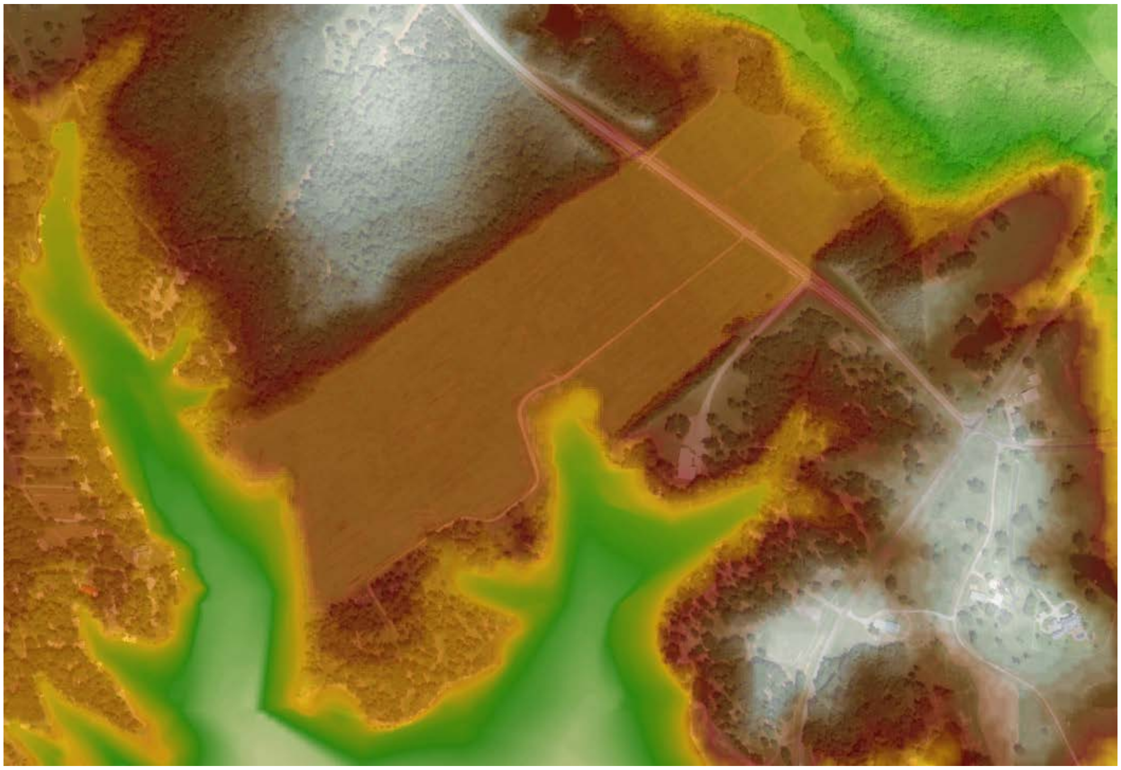


Figure 20: Finalized Alternative No. 2 (Design) Surface

5.5.3 Alternative No. 3A (Renovated): Surface Creation

Two additional alternatives (3A and 3B) were identified as possible solutions to renovation. These alternatives were evaluated for the purpose of balancing cost-savings to the District while maintaining hydraulic conveyance characteristics of the Emergency Spillway. In general, both of these alternatives involve the scraping or excavation of material and associated placement within the Emergency Spillway corridor on-site. In doing this, the excess material will be dispersed on-site instead of needing to be hauled off-site, thus saving the district additional costs in the renovation.

Using the Alternative No. 1 (Existing) surface and Alternative No. 2 (Design) surface, an Alternative No. 3A (Renovated) surface was created. This surface was developed by using volume differences between the existing and design surfaces to determine a suitable location that could handle the excess dirt. Additionally, the fill area locations were determined through preliminary hydraulic testing of the initial surface. The tests were run to highlight areas where water velocities were low and would not cause hydraulic issues due to the higher elevated portions of the renovated surface.

Proposed renovated surface Alternative 3A exhibits a similar elevation as the original design surface except where mounded material is placed on either side of the west portion of the spillway (Figure 21 below). Model results for the current condition exhibit low velocities in these regions and since less water is conveyed in these areas they appeared to be good candidates for mounding of fill material. For this renovated surface, both FM 3122 and the dirt road parallel to the emergency spillway are lowered along with their drainage ditches.

The hydraulic tests showed that the locations shown in Figure 21 were chosen as suitable areas.

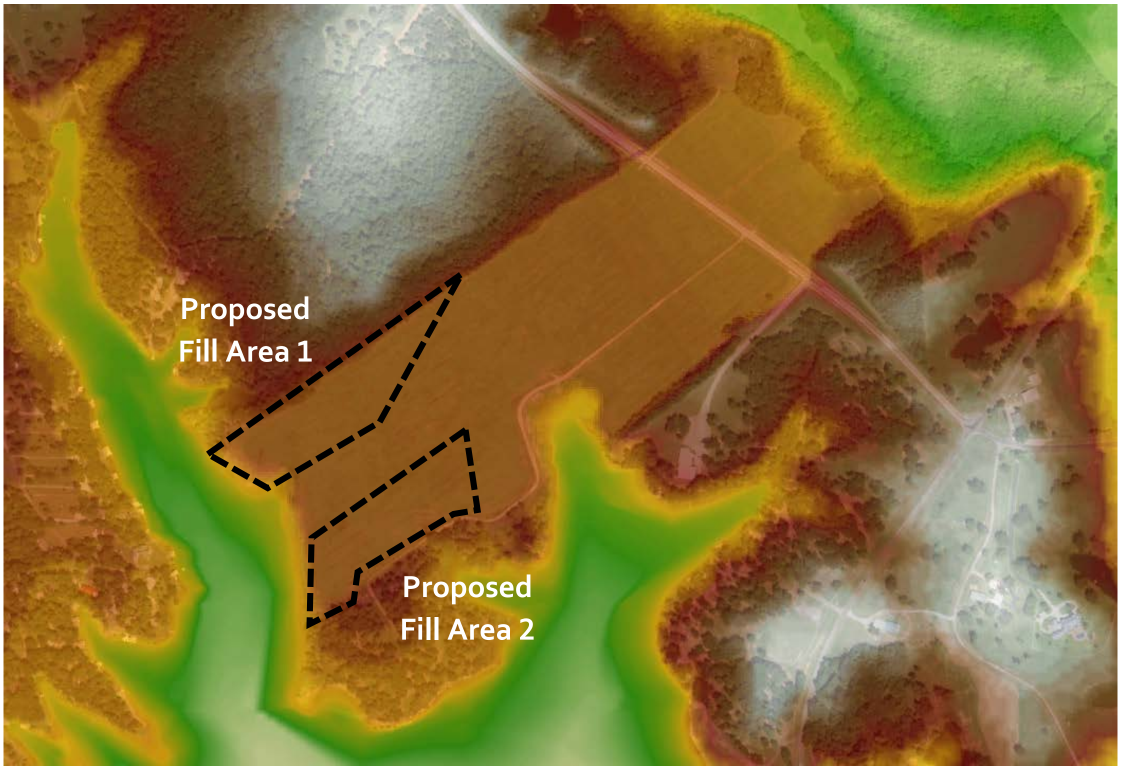


Figure 21: Proposed Locations of Fill for Alternative No. 3A (Renovated) Surface

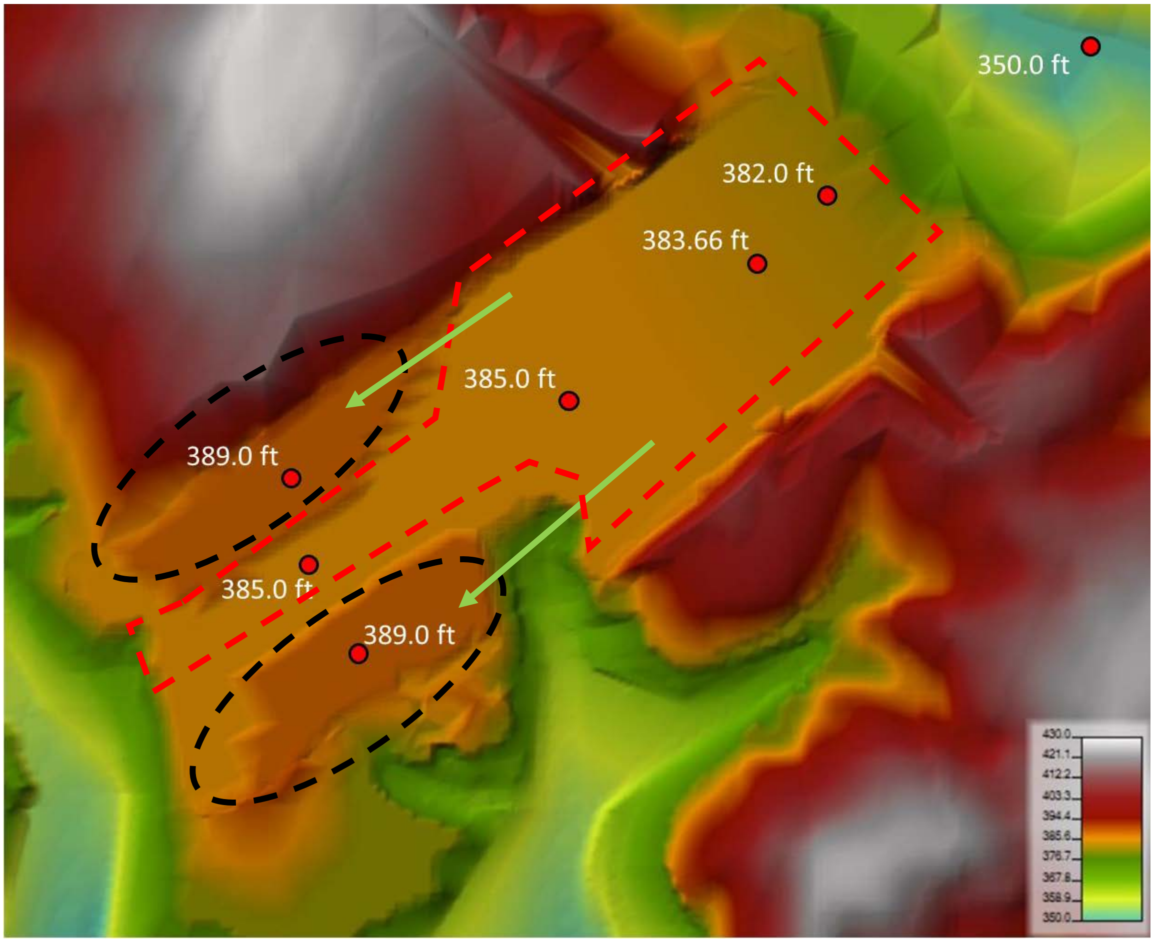


Figure 22: Alternative No. 3A (Renovated): Renovated Surface HEC-RAS Terrain

Shown in Figure 22 is the final Alternative No. 3A Renovated Surface. Regions of raised elevation (elevation of 389 feet) are in the lower left portion of the emergency spillway.

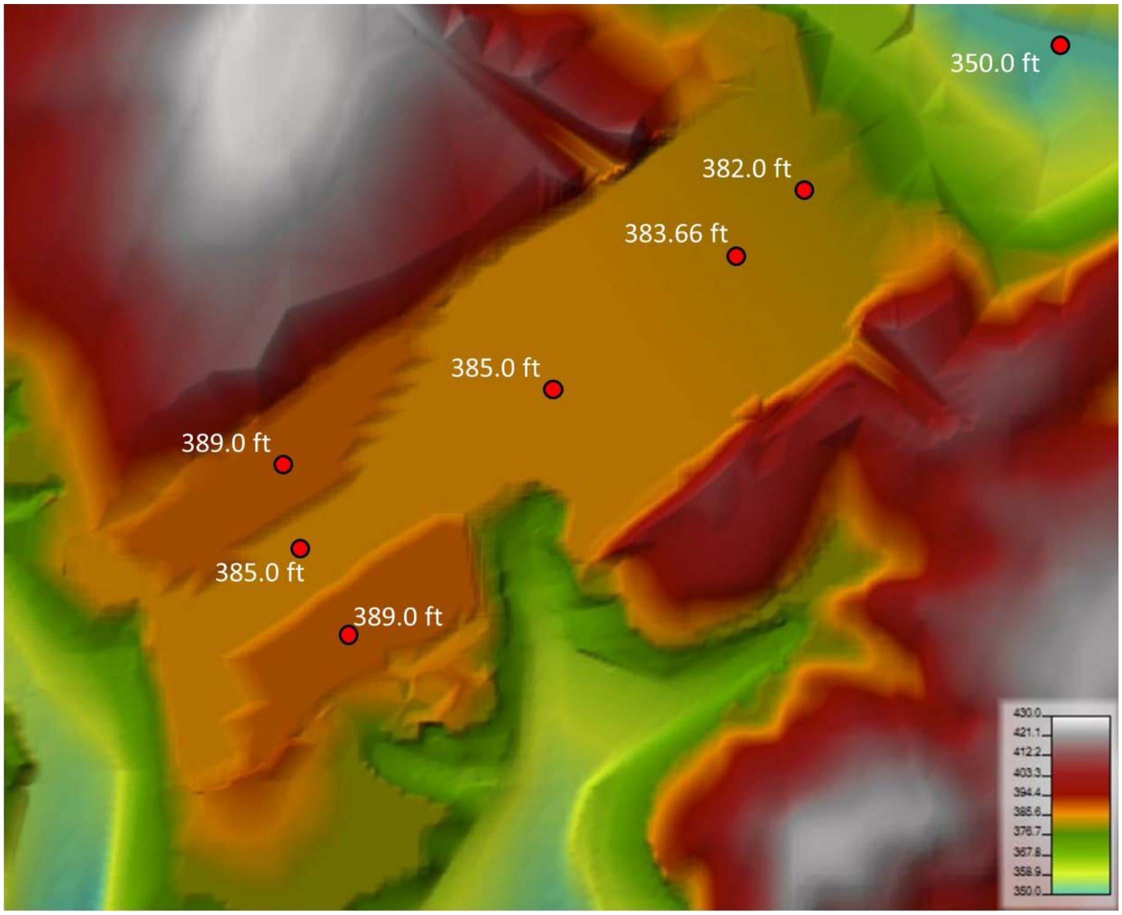


Figure 23: Finalized Alternative No. 3A Surface

5.5.4 Alternative No. 3B (Renovated): Surface Creation

The second proposed renovated surface (Alternative 3B) keeps FM 3122 and the dirt road parallel to the emergency spillway, but lowers the surrounding land elevation to their original design surface in regions upstream and downstream FM 3122. Fill material cut upstream of FM 3122 is mounded in a region near the lake at the west end of the spillway, and fill material cut downstream of FM 3122 is mounded along the southern edge of the spillway downstream of FM 3122. Two fill regions are used to avoid transporting cut material across FM 3122, which would require additional equipment. By doing this, the district can take advantage of additional cost savings. The Alternative No. 3B (Renovated) Surface is shown in Figure 24 below.

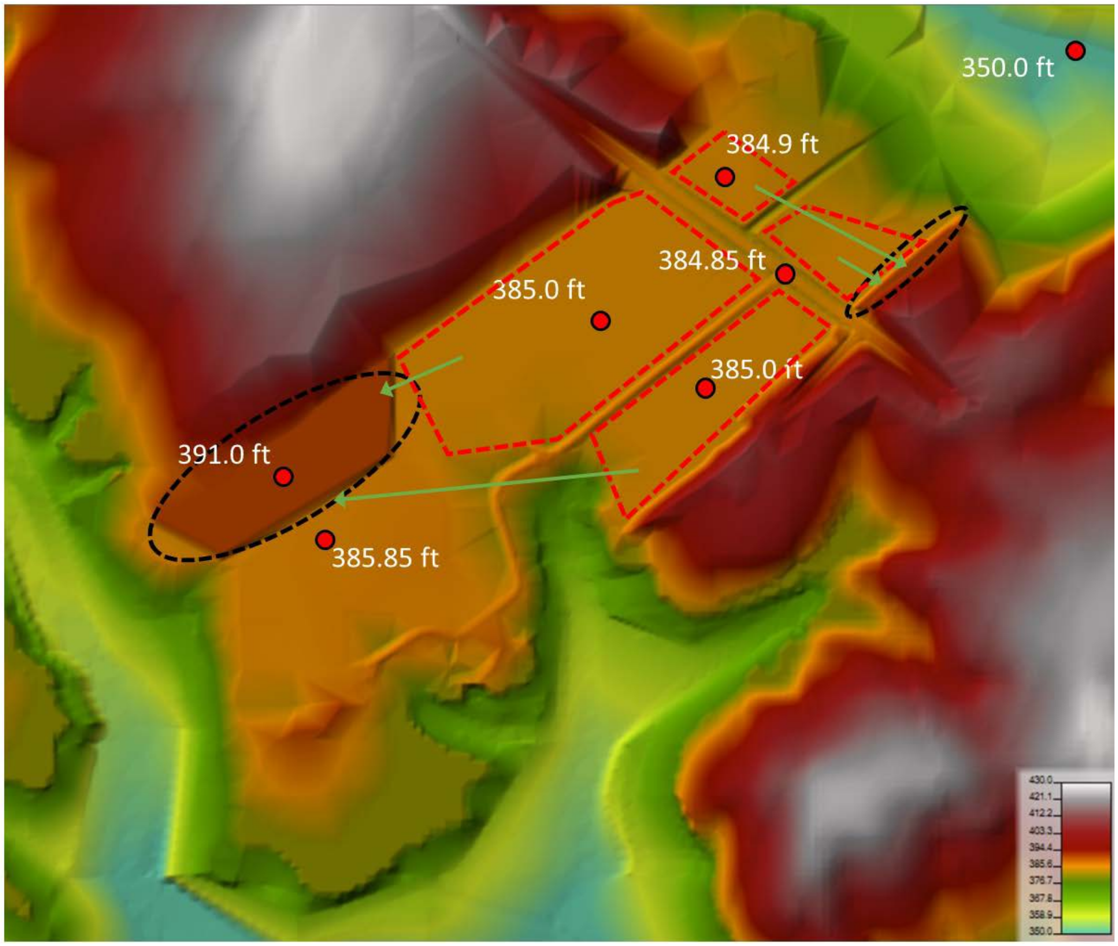


Figure 24: Finalized Alternative No. 3B Surface

5.6 Hydraulic Modeling of the Emergency Spillway

5.6.1 Model Development Background

As discussed earlier in this report, the recent 2006 survey provided by the District indicate that the current spillway area is not at the elevation originally designed at the time of construction of the dam. The purpose of this hydraulic modeling portion was to determine hydraulic characteristics of the current existing-condition spillway, then to determine the predicted characteristics of the original design spillway and of two proposed potential renovated spillway configurations. All four geometric scenarios, each incorporated into the hydraulic model as a 3-dimensional terrain, are modeled under the same Lake Cypress Springs water surface elevation timeseries.

5.6.2 Model Boundary Conditions / Topography Description

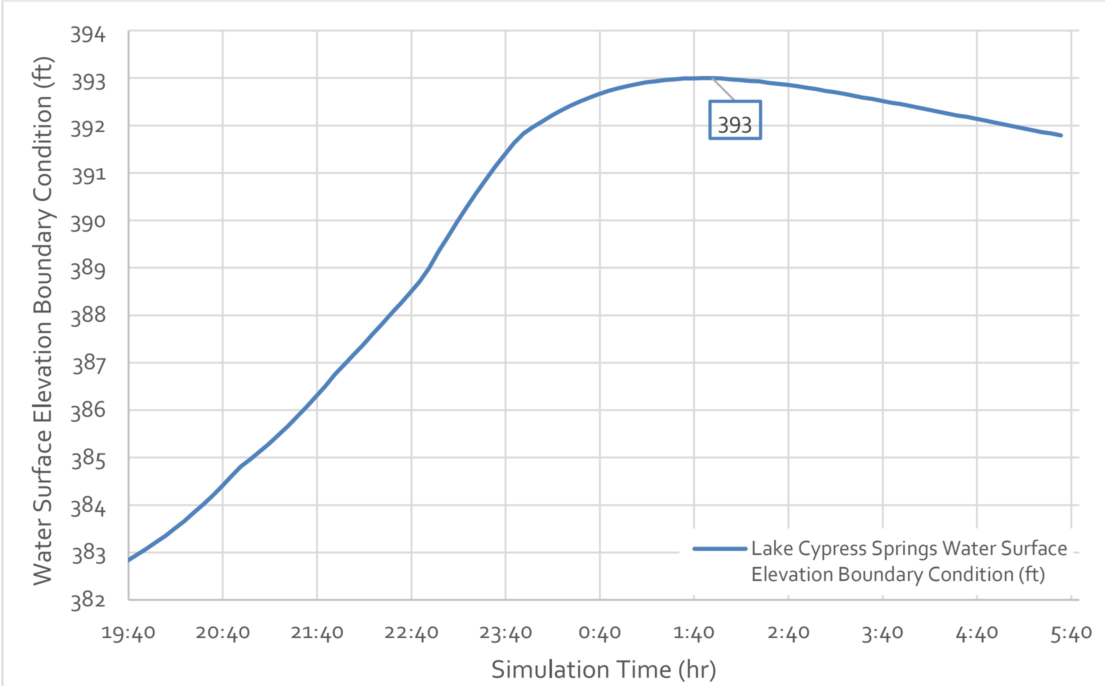
HEC-RAS v5.0.3 was used to perform the emergency spillway modeling and the modeling components are shown in Figure 25. The one major component in the model is the 2D Flow Area, which that extends from the north-eastern cove of Lake Cypress Springs, over the emergency spillway, along Andy's Creek, and ending above Lake Bob Sandlin (Figure 25). The 2D Flow Area has the following connections:

- The Lake Cypress Springs boundary condition (upstream from the west)
- Andy's Creek inflow (upstream from the north)
- Downstream boundary condition at the end of Andy's Creek (downstream to the southeast)

The 2D flow area connections include the Lake Cypress Springs boundary condition, an upstream boundary condition for Andy's Creek inflow, and a downstream boundary condition at the termination of Andy's Creek. The Lake Cypress Springs boundary condition is a water surface elevation timeseries and described further below. Andy's Creek upstream inflow was assumed to be 10,000 cfs throughout the modeling time period, which was a conservative assumption. The downstream boundary condition at Andy's Creek terminus was set as a normal depth, with a friction slope value of 0.0025. The purpose of including Andy's Creek flow in this model is to evaluate whether high flow in the creek impacts operation of the emergency spillway.

Figure 25: HEC-RAS Model Components

The Lake Cypress Springs boundary condition is a water surface elevation timeseries, shown in Figure 26. The rise and fall rate of the water surface timeseries is based on the Freese & Nichols PMF inflow HEC-RAS 1D model of Lake Cypress Springs. The water surface elevation timeseries used in the model starts at an elevation below the emergency spillway and rises to a maximum elevation of 393 feet. This maximum water surface elevation was chosen because it provides two feet of freeboard for the Franklin County Dam. The model's timestep was set at two seconds for model stability and to properly capture the high velocities on the emergency spillway. A summary of the model inputs are listed in Table 27.



Graph 26: Lake Cypress Springs Water Surface Elevation Timeseries Boundary Condition

Table 27: HEC-RAS Model Inputs

Input	Unit	Value
Timestep	Seconds	2
Start time	Day & Time	Day 1, 19:40
End time	Day & Time	Day 2, 05:34
Total simulation time	Hours	9.9
Starting water surface elevation	Feet	382.83
Lake Cypress Springs Water Surface Elevation Boundary Condition	Feet	Time series
Andy's Creek Inflow Boundary Condition	Cfs	10,000 cfs
2D modeling equation	--	Diffusive wave
Franklin County Dam Elevation	Feet	395

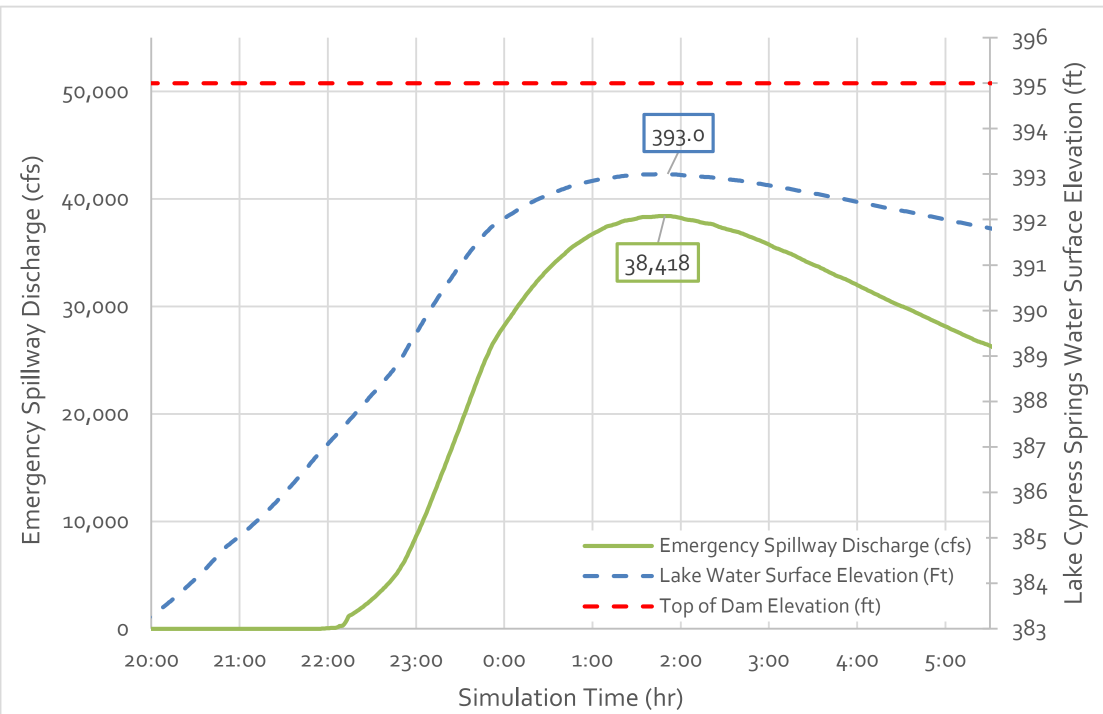
5.7 Alternative No. 1 (Existing) Model Results

Model results show that the peak flow rate over the emergency spillway is 38,418 cfs at time 25:52 (day 2, 01:52). This time corresponds to boundary condition peak water surface elevation in the 2D Flow Area at 393.0 feet (Graph 28). Again, this water surface elevation is chosen because it allows 2.0 feet freeboard below the crest of the Franklin County Dam.

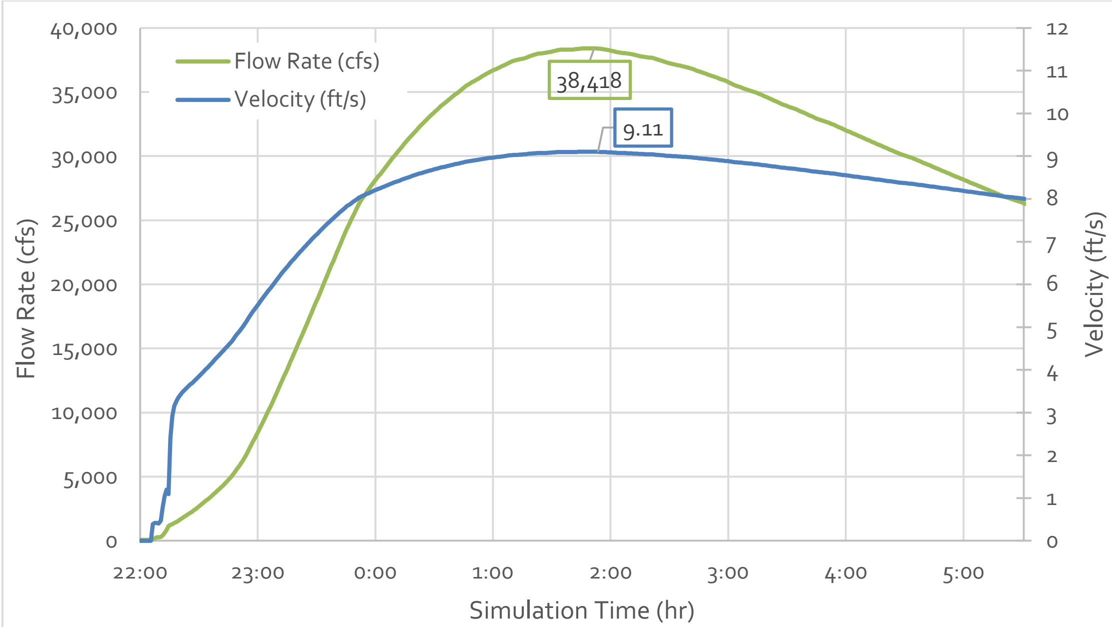
A timeseries of flow and velocity over the emergency spillway at the location of FM 3122 (Graph 29) reveals maximum velocity of approximately 9.1 feet/s over the road. A spatial map of velocity and particle tracking at the peak flow rate and other flow conditions are shown in Figure 30 and Figure 31. In Figure 32 a view of the peak flow rate velocities are shown over the unsurfaced driveway to the lease which runs perpendicular to FM 3122 and parallel to water flowing within the emergency spillway. Velocities of approximately 5.5 feet/s are exhibited perpendicular to that driveway in certain portions.

The 2D flow area was extended downstream of the emergency spillway along Andy's Creek to consider any effects from Andy's Creek and Lake Bob Sandlin. Figure 33 shows a profile, which travels along the emergency spillway and down into Andy's Creek. This profile shows the water surface elevations and velocities at the peak flow rate of 38,418 cfs on the emergency spillway. There is a significant water surface elevation drop at station 3,300 feet when the emergency spillway transitions down into Andy's Creek. Additionally, at the end of Andy's Creek when it discharges into Lake Bob Sandlin, the water surface elevation is 342.0 feet at the maximum flow rate in Andy's Creek. This water surface elevation of Andy's Creek where it discharges into Lake Bob Sandlin is 3.3 feet. For the flow condition assumptions in Andy's Creek it does not appear to be a downstream water surface elevation control on the emergency spillway.

Figure 34 and Figure 35 show point velocities and point water surface elevations across the 2D flow area during the peak flow rate of 38,418 cfs. Velocities around the leased land, which is located south of the emergency spillway, are around 0.24 feet/s.



Graph 28: Lake Cypress Springs water surface elevation (dashed line), emergency spillway discharge, and top of Franklin County Dam for Alternative 1 (Existing) surface.



Graph 29: Time series of flow rate and velocity on FM 3122 roadway perpendicularly crossing emergency spillway for the Alternative 1 (Existing) surface.

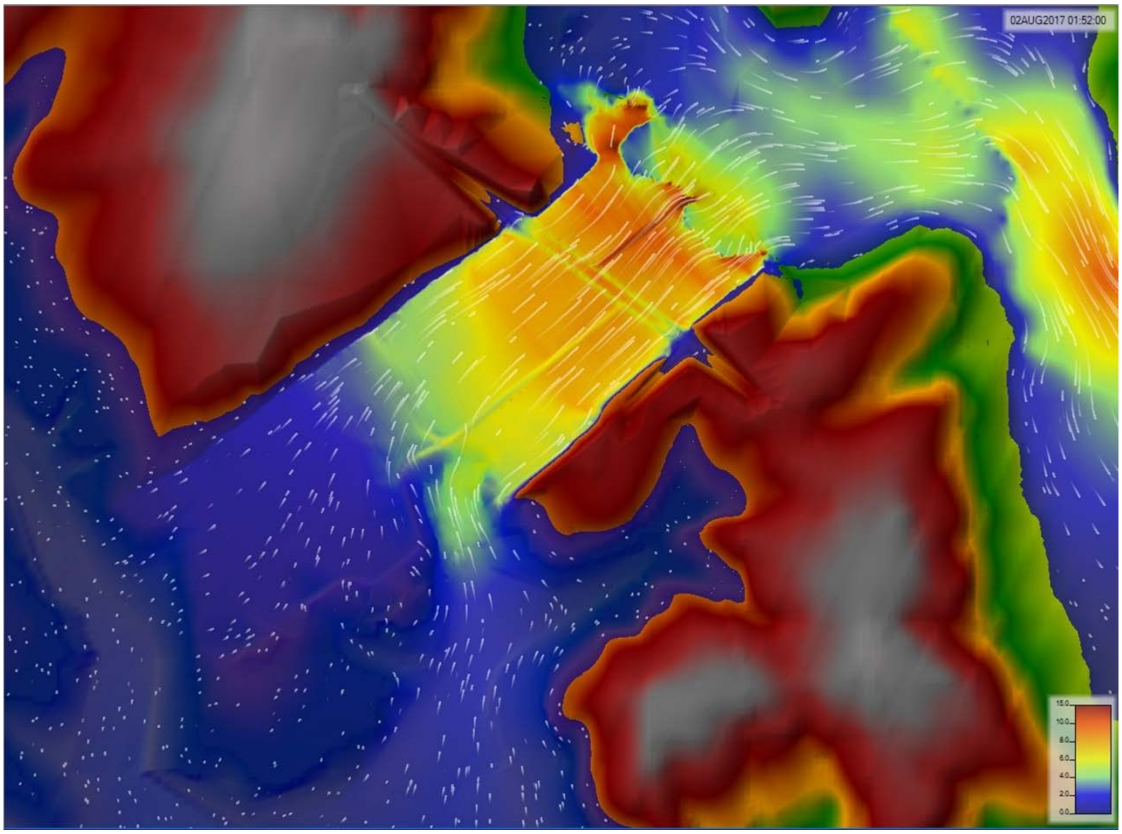


Figure 30: Velocity color contours in feet/s at peak flow rate of 38,418 cfs for the Alternative 1 (Existing) surface.

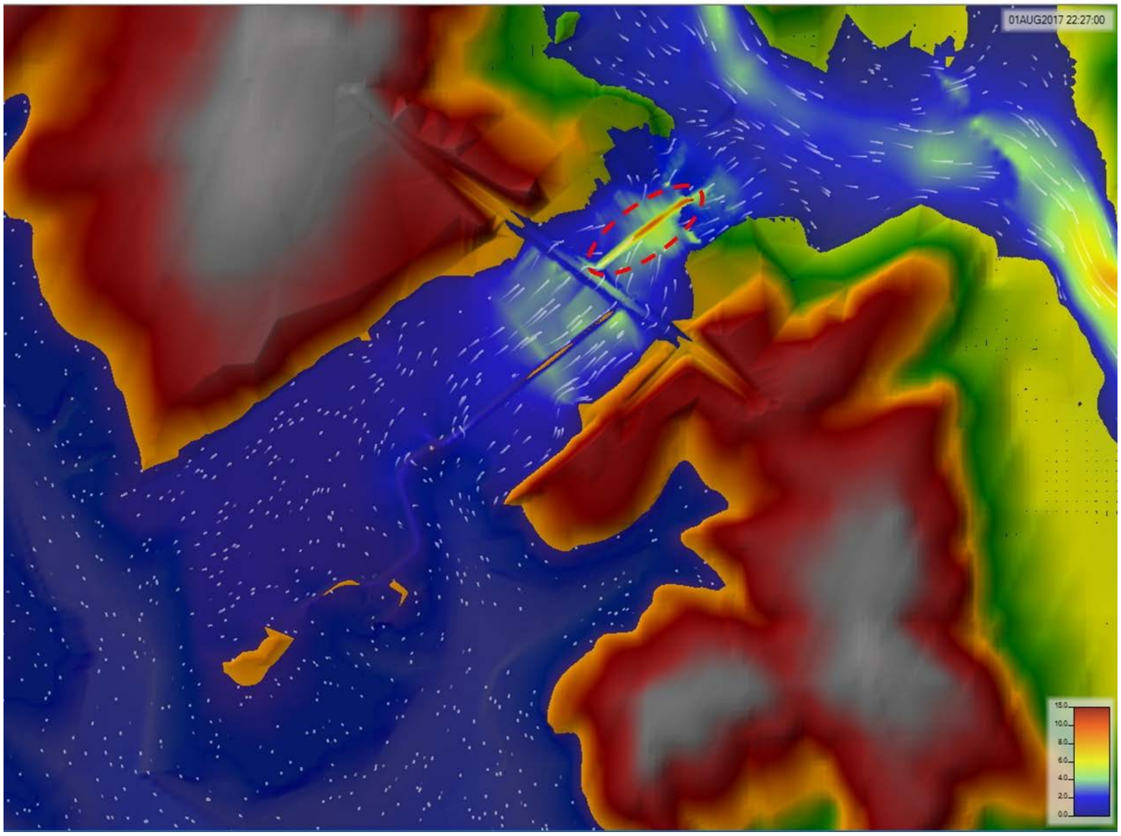


Figure 31: Velocity color contours in feet/sec when water elevation just begins to overflow the emergency spillway at 386 feet and flow rate is 2,277 cfs, at FM 3122 for the Alternative 1 (Existing) surface.

As shown in Figure 31, the line of higher velocity downstream (east) of the emergency spillway (circled in red) is an existing drainage ditch.

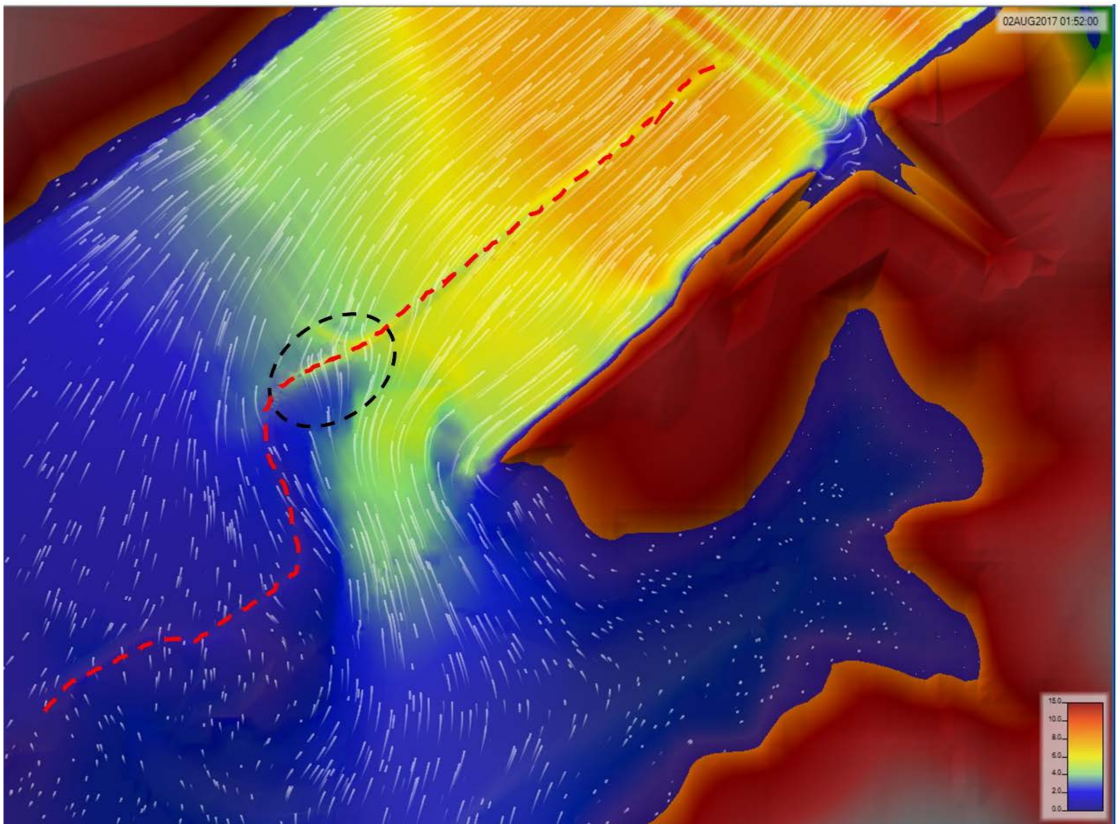


Figure 32: Velocity color contours in feet/s on the emergency spillway at peak flow rate of 38,418 cfs for the Alternative 1 (Existing) surface.

In Figure 32 above, outlined in red is the existing unsurfaced roadway to the lease, and the black circled region is the unsurfaced road where flow velocity is perpendicular to that road.

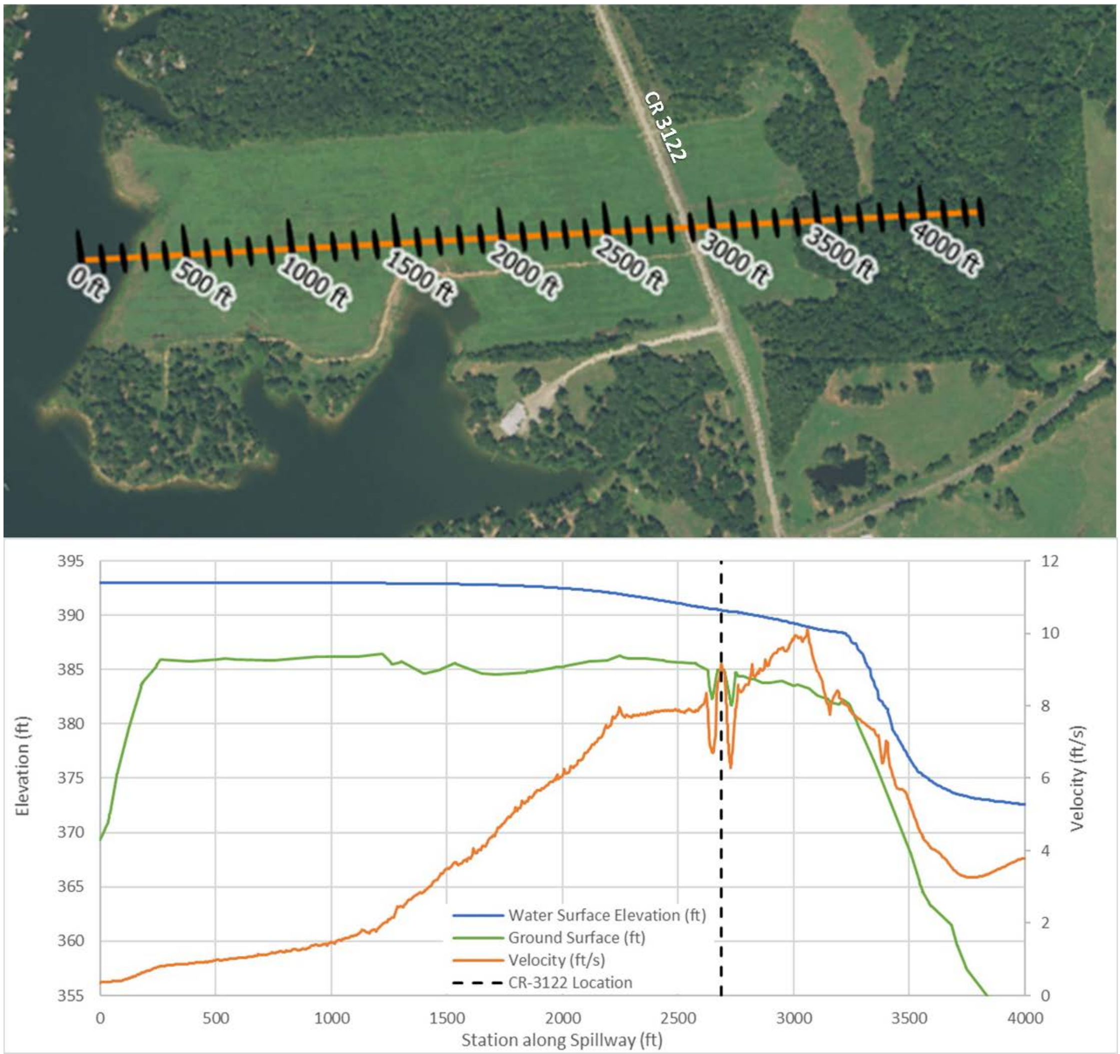


Figure 33: Andy's Creek Alternative 1 (Existing) Surface.

Figure 33 above is split into two parts. Top: station location line along the emergency spillway and into Andy's Creek. Bottom: profile of ground surface (green), water surface elevation (blue) and velocity (orange) at peak flow rate of 38,418 cfs along emergency spillway and ending at Andy's Creek for the Alternative 1 (Existing) surface.

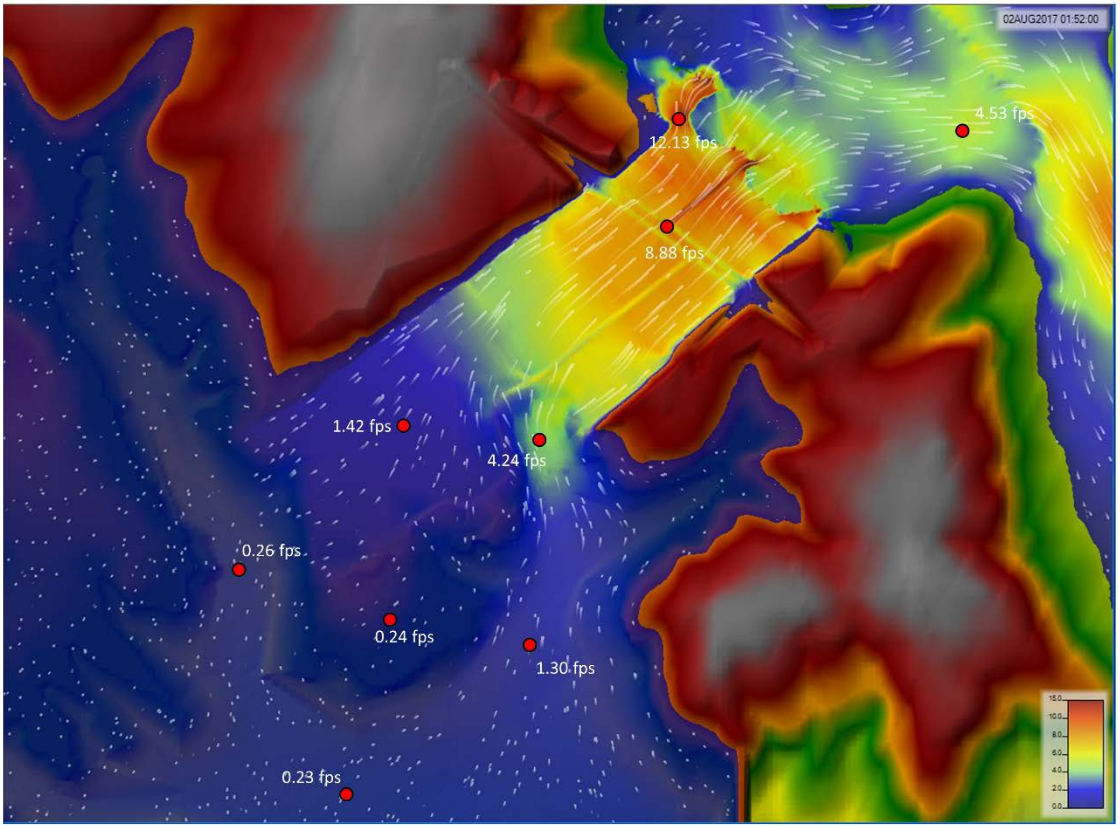


Figure 34: Velocity color contours in feet/s and point velocities (red dots) at the peak flow rate of 38,418 cfs over the emergency spillway for the Alternative 1 (Existing) surface.

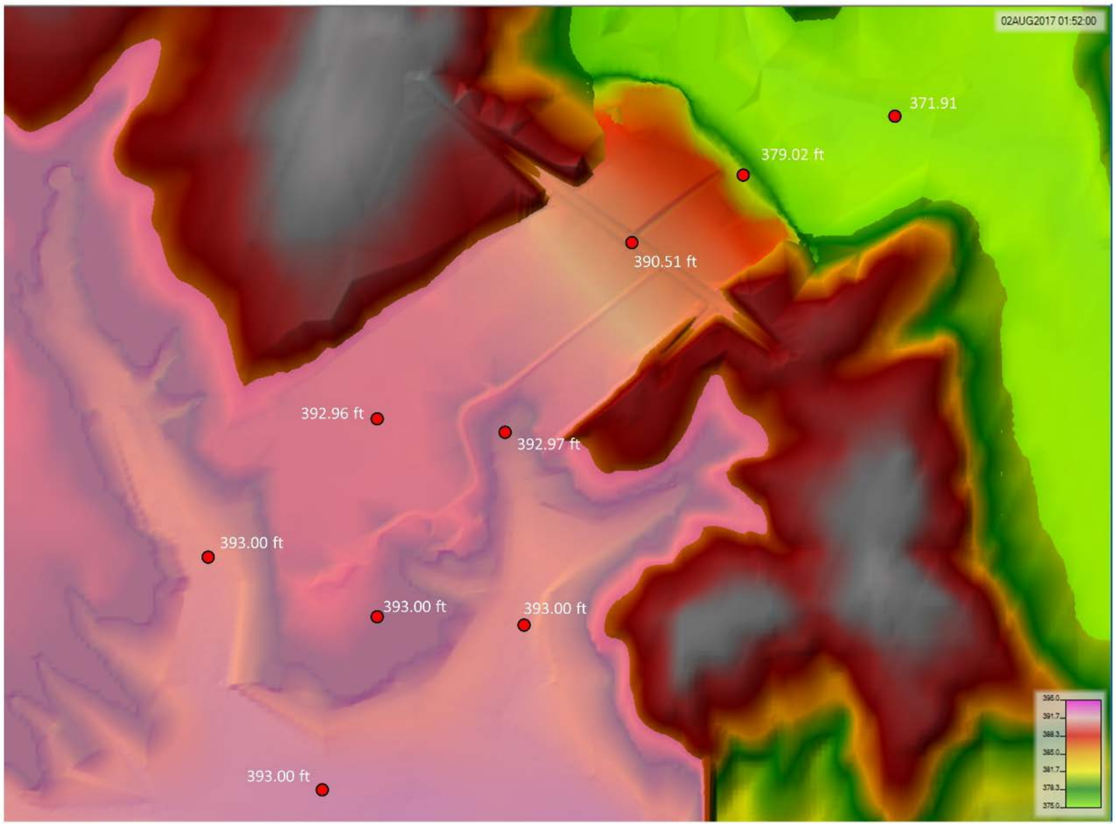
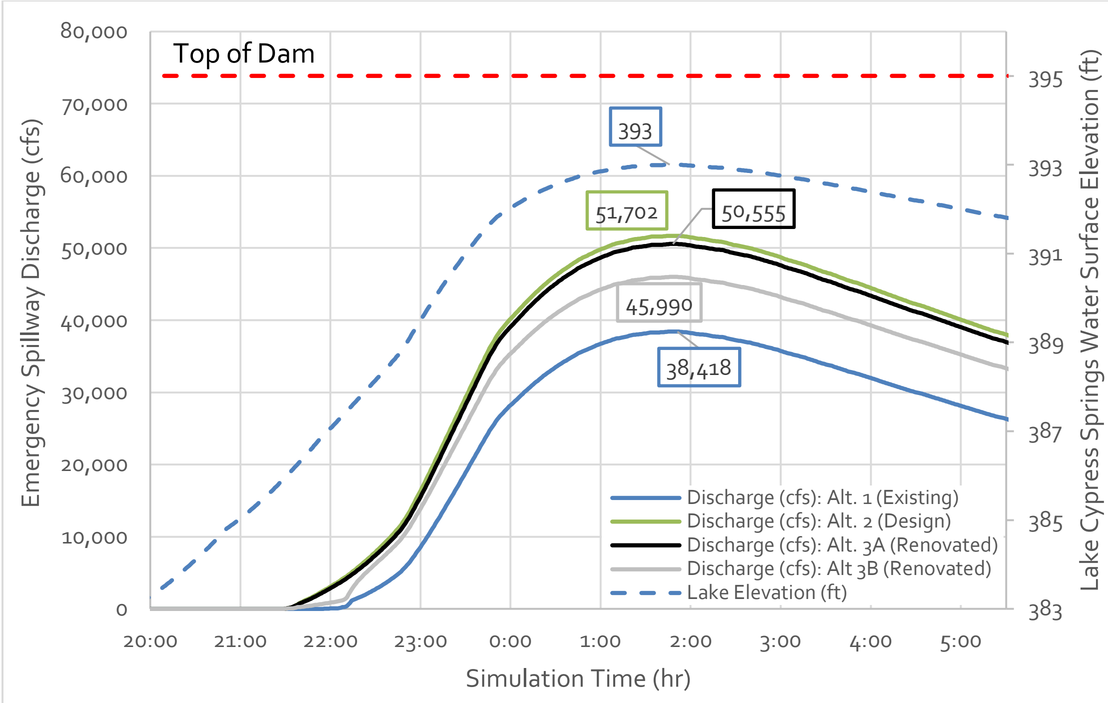


Figure 35: Point water surface elevations (ft) at the peak flow rate of 38,418 cfs over the emergency spillway for the Alternative 1 (Existing) surface.

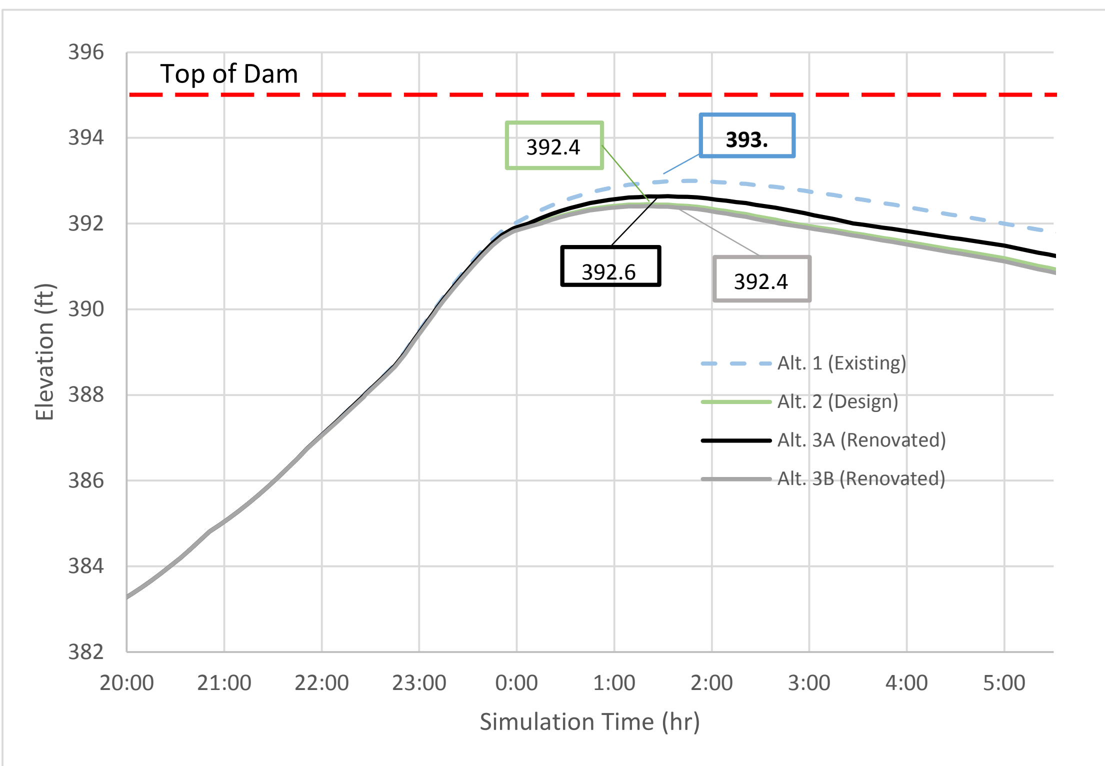
5.8 Alternative Nos. 2/3A/3B Model Results

Graph 36 and 37 are two of the most important graphs in the analysis. They depict the model results for Alternatives 1, 2, 3A, and 3B surfaces. For the existing condition (Alternative 1), the emergency spillway discharge is from 7,570 to 13,280 cfs lower than the original design or renovated conditions. This is expected because of the proposed decrease in the emergency spillway's elevation in regions that likely restrict flow.

Maps of velocity and particle tracking at the peak flow rate for the Alternative 2 (Design), Alternative 3A (Renovated), and Alternative 3B (Renovated) surfaces are shown in Figure 38, Figure 39, and Figure 40, respectively. As discharge rates are higher than the original model, the velocities on the emergency spillway are generally higher.



Graph 36: LCS water surface elevation and emergency spillway discharge for the Alternative 1, 2, 3A, and 3B surfaces. The peak discharges are labeled for each alternative and are color coded.



Graph 37: LCS Water Surface Elevation Over the Model Time.

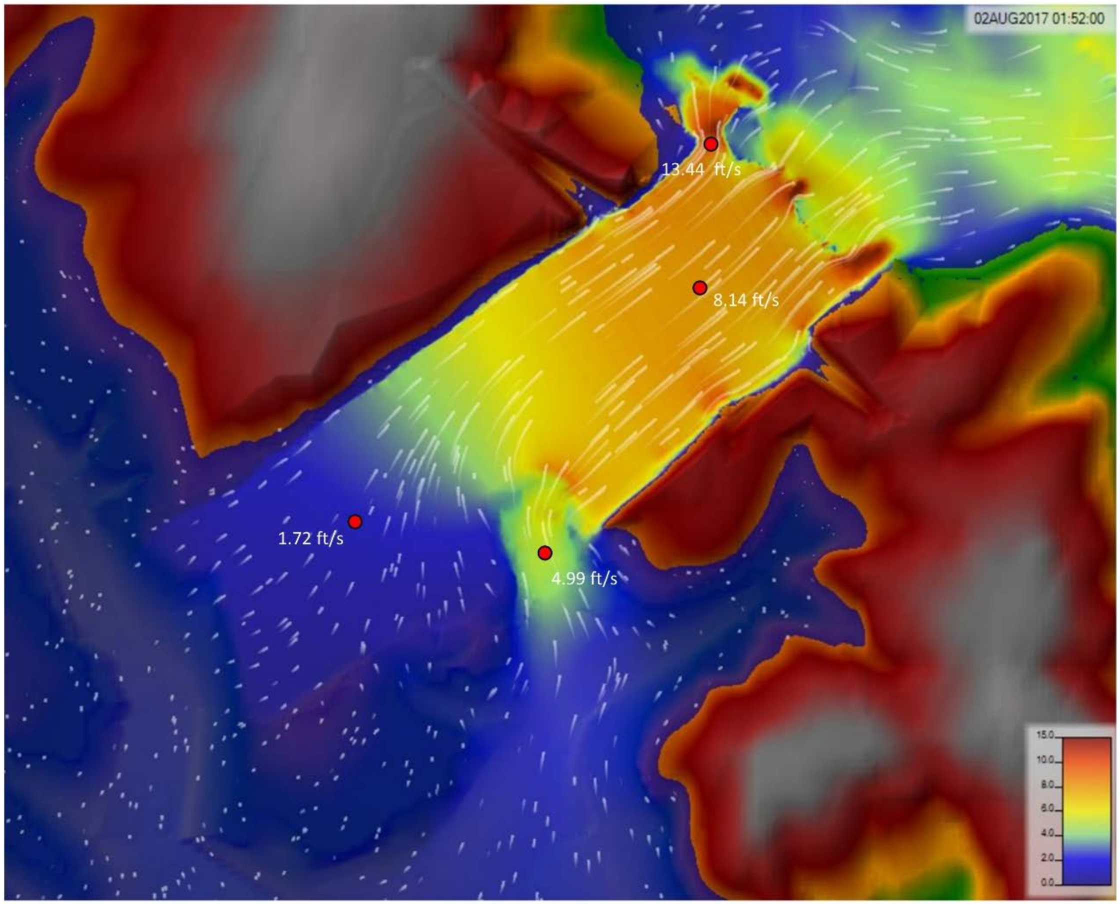


Figure 38: Velocity color contours in feet/s and point velocities (red dots) at peak flow rate of 51,702 cfs for the Alternative 2 (Design) surface.

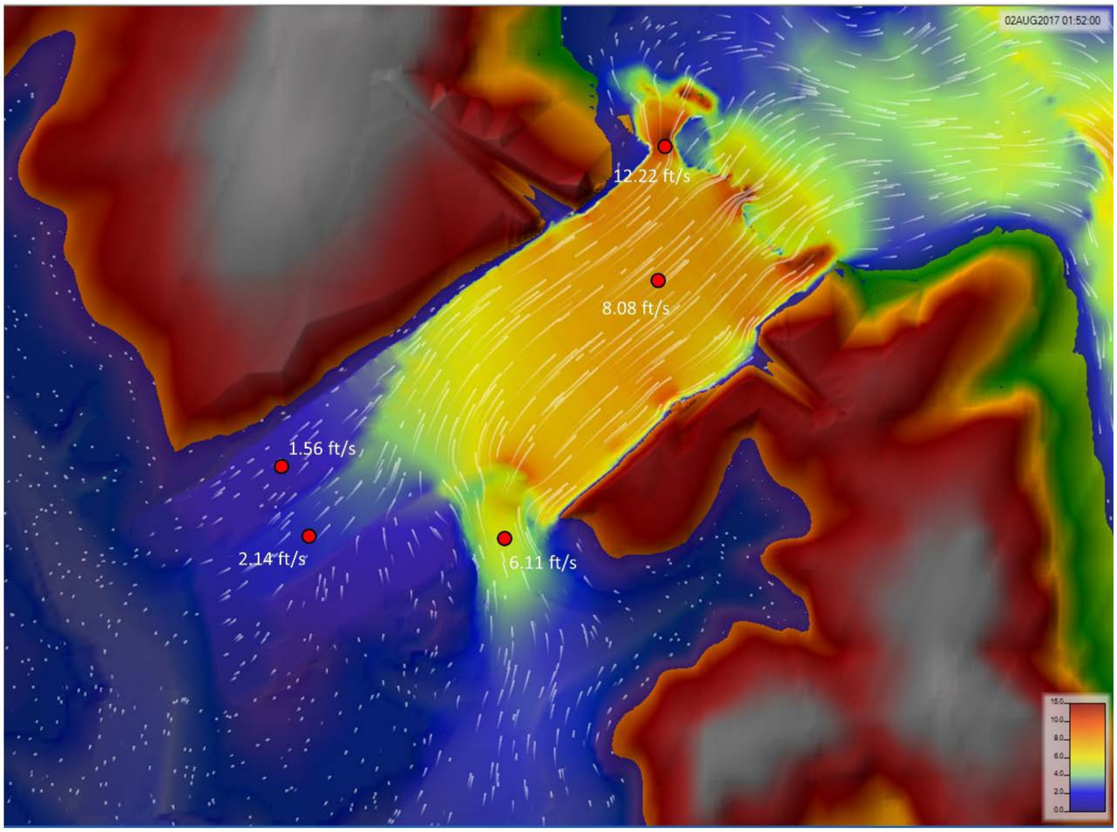


Figure 39: Velocity color contours in feet/s and point velocities (red dots) at peak flow rate of 50,555 cfs for the Alternative 3A (Renovated) surface.

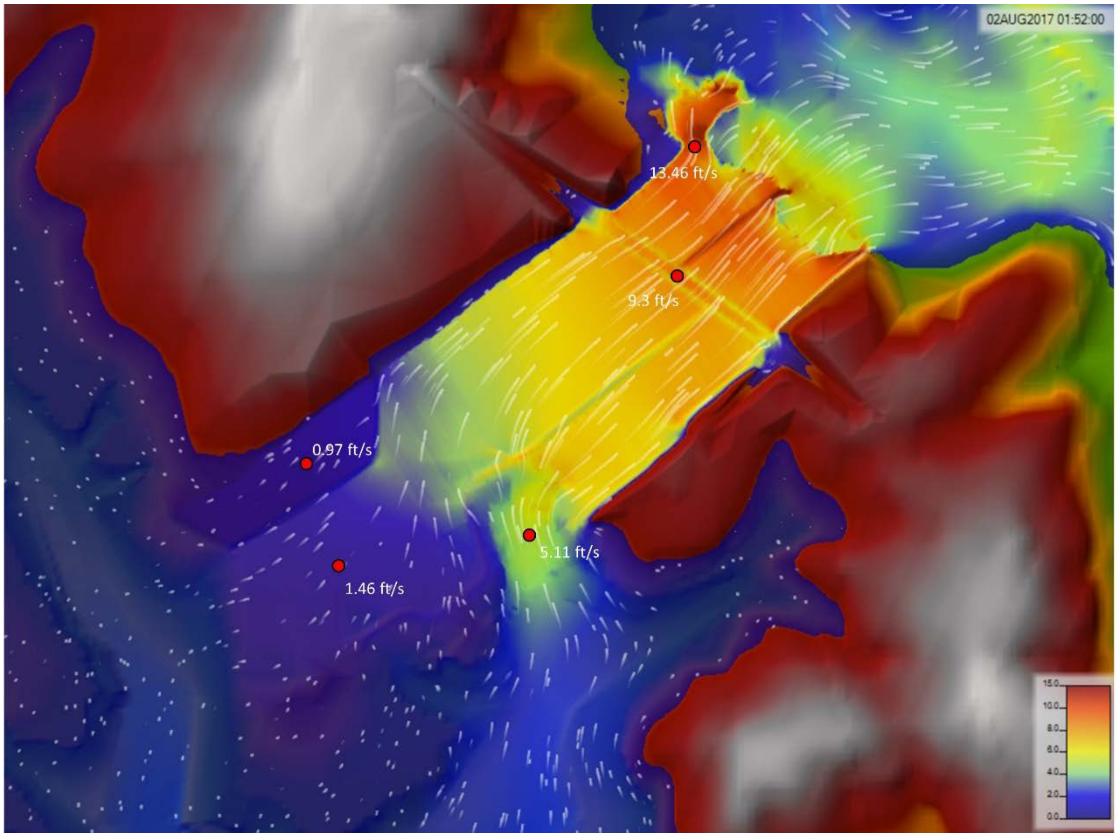


Figure 40: Velocity color contours in feet/s and point velocities (red dots) at peak flow rate of 45,990 cfs for the Alternative 3B (Renovated) surface.

5.9 Model Sensitivity to Roughness

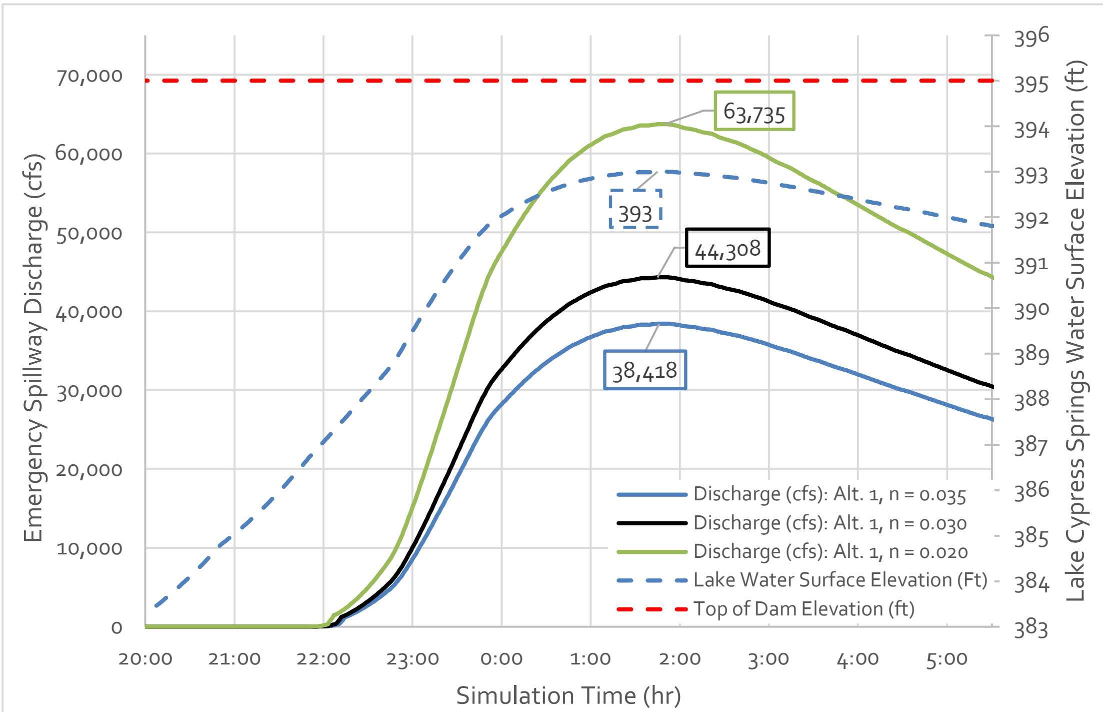
To test the model's sensitivity to the selected Manning's roughness, two sensitivity scenarios were evaluated using the Alternative 1 (Existing) surface (see Table 41 for the original roughness). The Alternative 1 (Existing) surface has a Manning's roughness value of 0.035, defined as a normal value for pasture with no brush and high grass, or mature cultivated row crops (Chow, 1959). A sensitivity model scenario uses an emergency spillway roughness of 0.03, defined as a normal value for short grass in a pasture with no brush. Another sensitivity model scenario uses an emergency spillway roughness of 0.02, defined as a minimum value for a cultivated area with no crop.

Table 41 shows the maximum discharge over the emergency spillway for each sensitivity model using the same water surface elevation timeseries as the previous alternative surface models. Graph 42 is a timeseries of the emergency spillway discharges for the sensitivity analysis models.

Decreasing the Manning's roughness to 0.03 and 0.02 increases the emergency spillway discharge by 5,890 and 25,317 cfs, respectively. Mowing, as reflected by the results of the 0.03 scenario, can have significant effect on hydraulic conveyance.

Table 41: Current Surface, Results of Analysis of Sensitivity to Manning's n Roughness

Emergency Spillway Manning's Roughness Value	Maximum Emergency Spillway Discharge (cfs)
0.035 - High-grass pasture no brush (Alternative 1 current condition value)	38,418
0.030 - Short grass pasture no brush	44,308
0.020 - Cultivated no crop, clean bare earth or concrete	63,735



Graph 42: Manning's roughness sensitivity analysis emergency spillway discharge timeseries for the Alternative 1 (Existing) surface.

5.10 Shear Stress & Erosion Potential

Areas of high shear stress and/or velocity can result in erosion or scouring. Table 43, adapted from the Bureau of Reclamation, lists permissible shear stresses and velocities based on soil or vegetation type. The mid-range of allowable values for areas with an established ground cover of "long native grasses" is 1.5 lb/ft^2 for shear stress and 5 feet/s for velocity (Table 43). Figure 44 through Figure 46 show shear stresses at the peak flow rate (which corresponds to the maximum shear stress) for Alternative 1, 2, 3A, and 3B. For all modeled surfaces there are large areas of the emergency spillway, including FM 3122, that have modeled shear stresses within or above the permissible range and are at risk of erosion or scouring during the modeled event.

Table 43: Permissible shear stress and velocity for soils, gravel and vegetation (Bureau of Reclamation Bank Stabilization Design Guidelines, Report No. SRH-2015-25, 2015).

Boundary Category	Bank Material Type	Permissible Shear Stress (lb/sq feet)	Permissible Velocity (ft/sec)
Soils	Fine colloidal sand	0.02 – 0.03	1.5
	Sandy loam (noncolloidal)	0.03 – 0.04	1.75
	Alluvial silt (noncolloidal)	0.045 – 0.05	2
	Silty loan (noncolloidal)	0.045 – 0.05	1.75 – 2.25
	Firm loam	0.075	2.5
	Fine gravels	0.075	2.5
	Stiff clay	0.26	3 – 4.5
	Alluvial silt (colloidal)	0.26	3.75
	Graded loam to cobbles	0.38	3.75
	Graded silts to cobbles	0.43	4
	Shales and hardpan	0.67	6
Gravel/Cobble	1-inch	0.33	2.5 – 5
	2-inch	0.67	3 – 6
	6-inch	2.0	4 – 7.5
	12-inch	4.0	5.5 – 12
Vegetation	Class A turf	3.7	6 – 8
	Class B turf	2.1	4 – 7
	Class C turf	1.0	3.5
	Long native grasses	1.2 – 1.7	4 – 6
	Short native and bunch grass	0.7 – 0.95	3 – 4
	Reed plantings	0.1 – 0.6	N/A
	Hardwood tree plantings	0.41 – 2.5	N/A

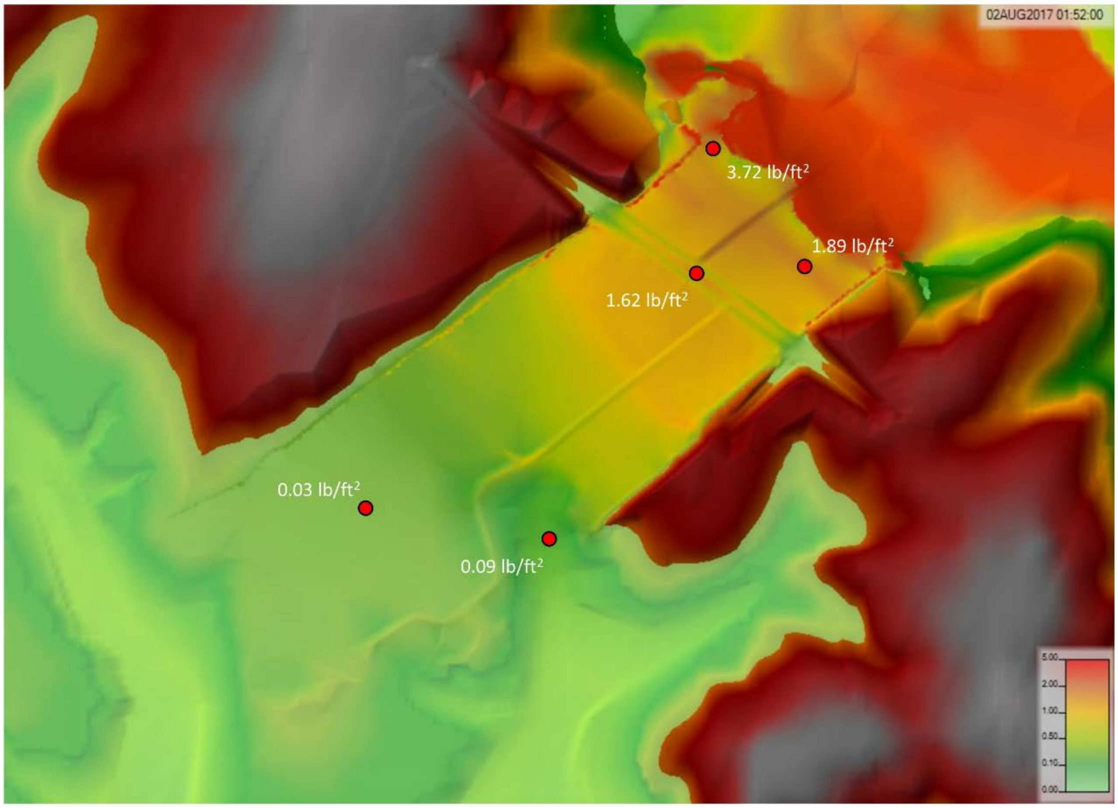


Figure 44: Shear stress color contours (lb/ft2) and point shear stress values at peak flow rate of 38,418 cfs (which corresponds to maximum shear stress) for the Alternative 1 (Existing) surface.

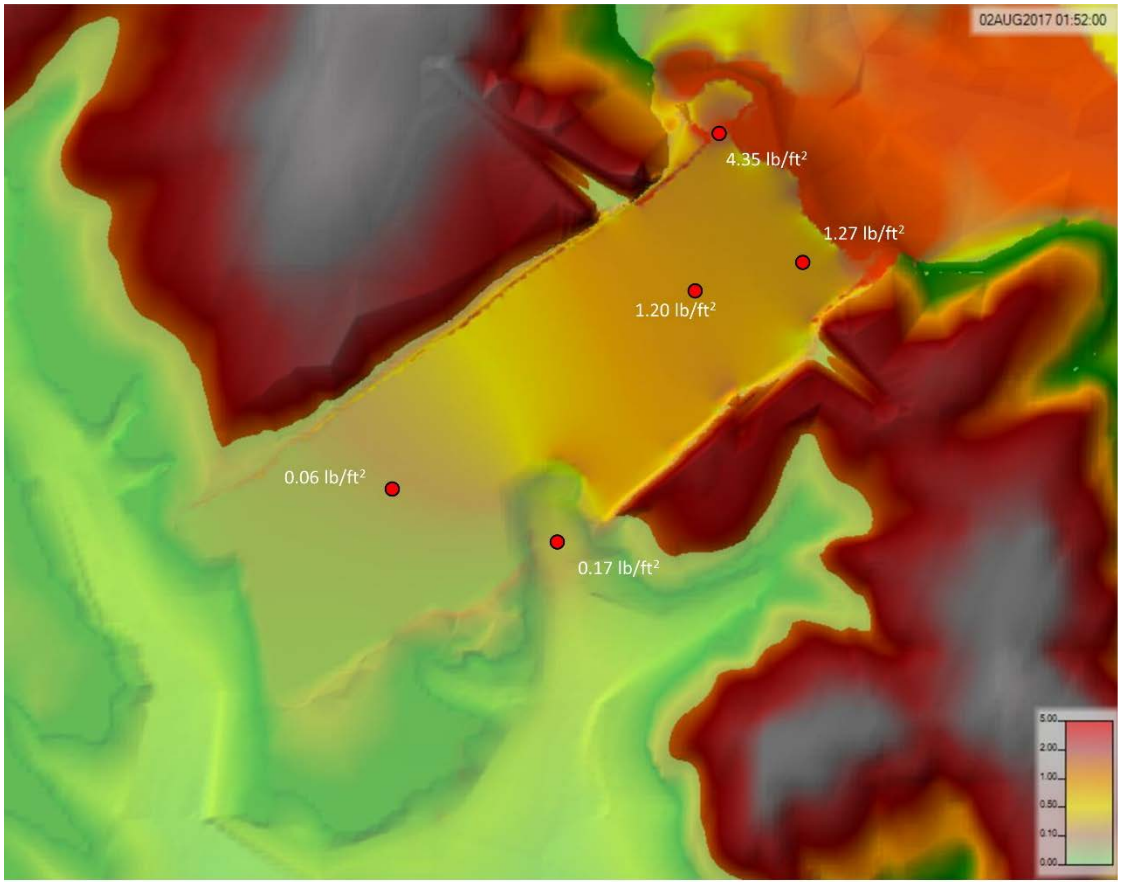


Figure 45: Shear stress color contours (lb/ft2) and point shear stress values at peak flow rate of 51,702 cfs (which corresponds to maximum shear stress) for the Alternative 2 (Design) surface.

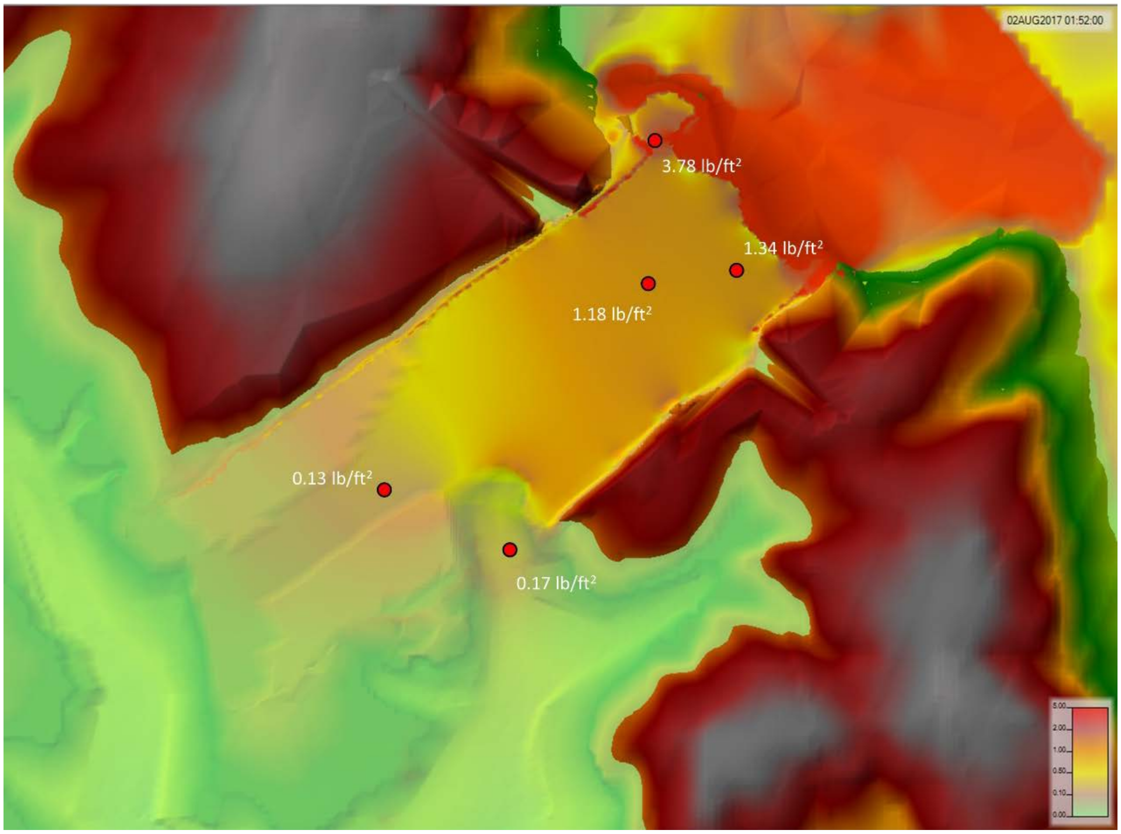


Figure 46: Shear stress color contours (lb/ft2) and point shear stress values at peak flow rate of 50,555 cfs (which corresponds to maximum shear stress) for the Alternative 3A (Renovated) surface.

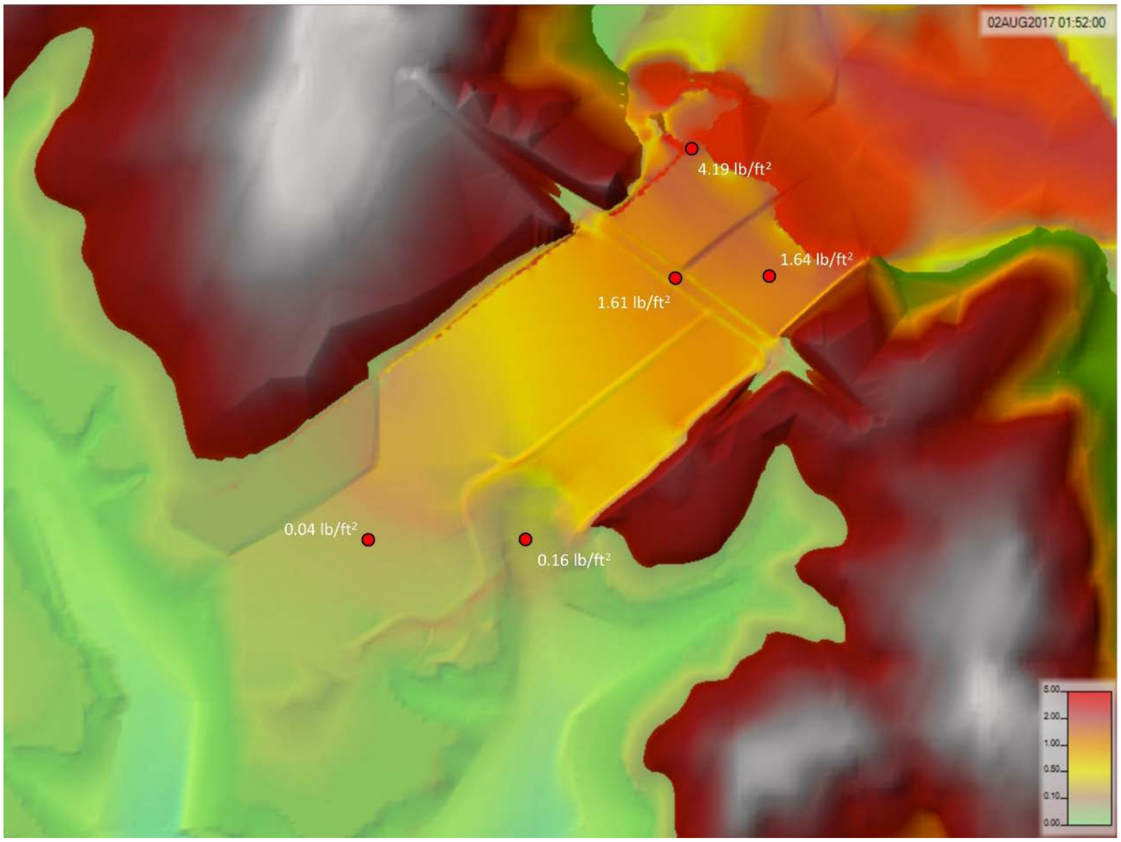


Figure 47: Shear stress color contours (lb/ft2) and point shear stress values at peak flow rate of 45,990 cfs (which corresponds to maximum shear stress) for the Alternative 3B (Renovated) surface.

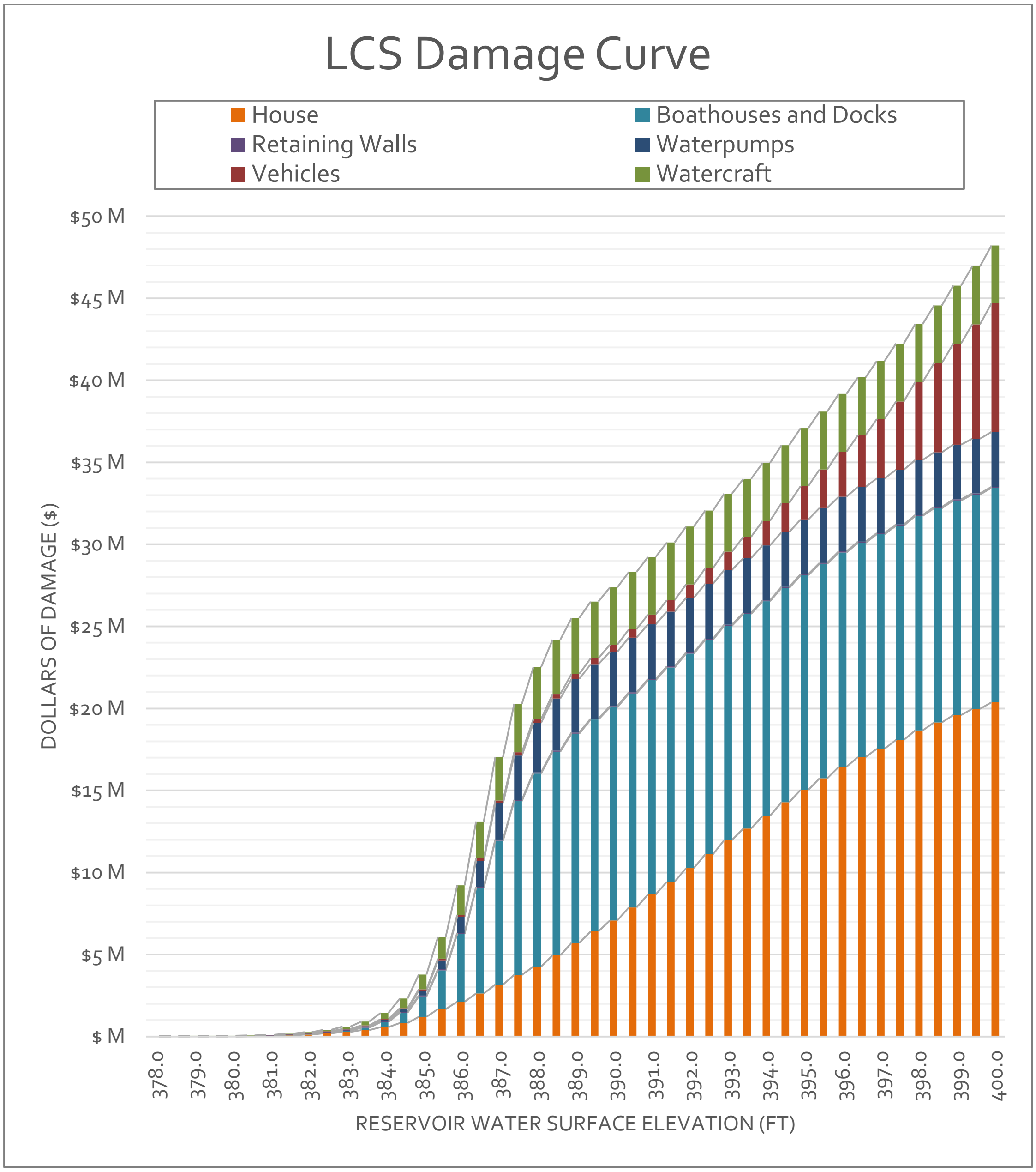
6.0 The Damage Curve and BC Ratio

6.1 Damage Curve Elements

The damage curve is a useful tool in correlating the water surface elevation and the amount of damage that can be expected around LCS at each given water surface elevation. The damage curve was developed in the previous flood evaluation PER and consists of various surveys of the homes that were damaged in the 2015 storm event. These surveys provide the data necessary to create correlation between the WSE surface rising and the estimated damage.

6.1.1 Creating the Damage Curve

Graph 48 below shows the total damage curve created from an accumulation of the damage curve elements, depicting the amount of damage in dollars at different WSEs in the reservoir. The graph shows the approximated cost of damage to houses, boathouses and docks, retaining walls, water pumps, vehicles, and watercraft at each water surface elevation around the lake.



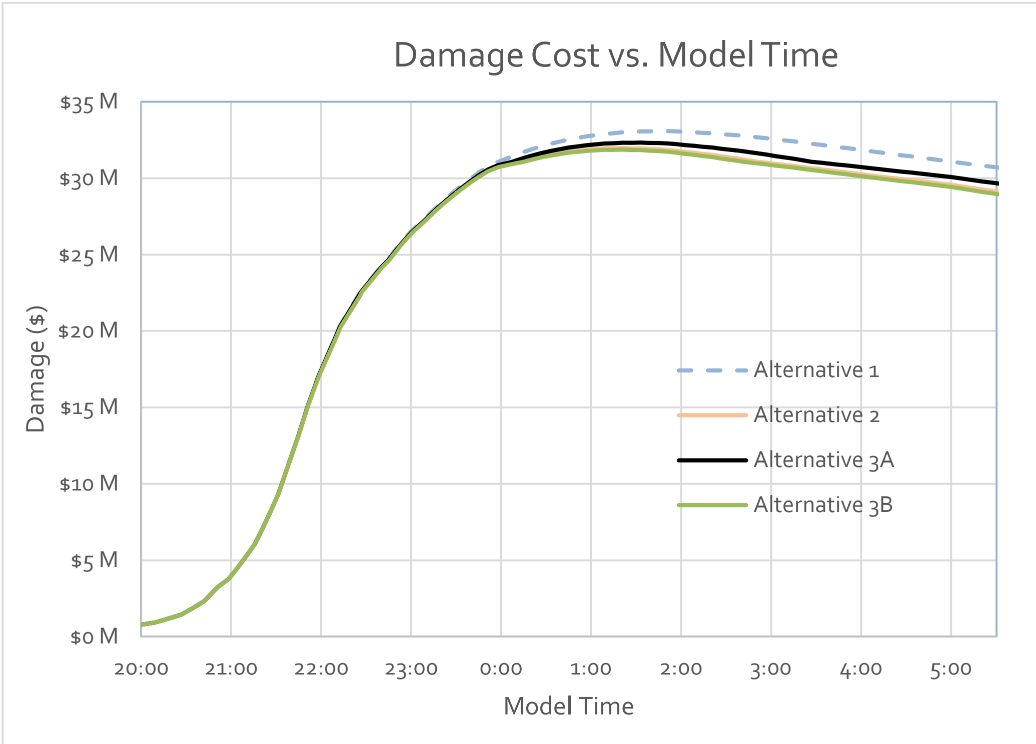
Graph 48: Total LCS Damage Curve

According to the figure, damage begins when the WSE rises to 380' msl. However, it does not significantly increase until 385' msl. At that point, the reservoir will experience much greater damage per foot of WSE rise.

6.2 Incorporating Model Data to Damage Curve

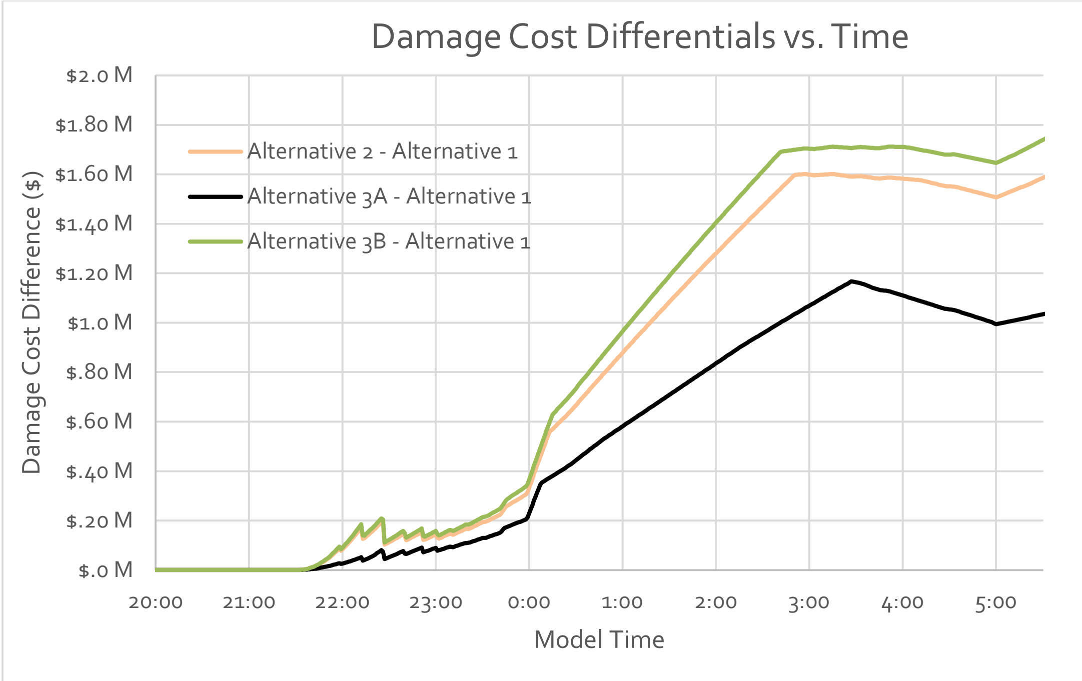
Data taken from the hydraulic models was used to create graphs to showcase the effect that each surface had on the total damage. These models were generated by taking the water flow rates measured across a 10 hour span during the hydraulic testing, calculating water elevations, and applying them to the damage survey acquired from the last report. In doing so, the water level elevations of each surface were joined to a value representing the total damage that would be accrued by each alternative at a specific time in the storm event. This data is useful in weighing the benefits of each surface and evaluating the amount of damage that can be expected.

Graphs were generated to help highlight the benefits of the design and renovated surfaces. The figure below in Graph 49 illustrates the damage cost differences between each surface.



Graph 49: Model Time vs. Damage Cost

Differences in damages between the alternatives were only significant in larger storm events where the water surface elevation in LCS rose significantly. To zoom in on the differences, a Damage Cost Difference graph was created to illustrate the beneficial potential of each surface (Graph 50 below). This graph shows the Damage cost differences of each surface (Alternative 2, 3A, and 3B) compared to the existing conditions surface (Alternative 1).



Graph 50: Damage Cost Differentials

This graph depicts the elevation differences between the surfaces. This data helps to highlight the increase in elevation due to storm events of each surface which is directly related to the damage amount.

By plotting each surface's Time vs. Damage Cost graph against one another, the damage cost differentials became apparent. As expected the Alternative 2, 3A, and 3B surfaces, through the course of the simulation, accrued less damage cost than the existing surface.

7.0 OPINION OF PROBABLE CONSTRUCTION COST

7.1 Comparison of Alternative Costs

The OPCC represents an estimate of what a proposed engineering project would cost, in today's dollars. These costs include an approximation of costs necessary to investigate, permit, engineer/design, and construction a proposed project. They also include a 20 percent contingency, consistent with industry standard for planning estimates of this nature. The OPCC does not included the cost of FCWD staff necessary to support the project, nor does it include some of the documented unknowns, primarily land acquisition needs if required.

A summary version of the OPCC is presented below in Table 51 below. A detailed OPCC that breaks the category items into individual takeoff items can be found in Appendix C: OPCC.

Table 51: Opinion of Probable Construction Cost (OPCC)

ALTERNATIVE 2 PROPOSED COSTS		
Start-Up, Mobilization, Security, & SW3P Items		$85,050
Emergency Spillway Dirt Work Items		$870,000
FM 3122 Road Renovation Items		$162,500
Design Fees (Survey, Geotech, Engineering, etc.)		$187,633
CONTINGENCY	**20%**	$261,036.50
TOTAL:		**$1,566,000**

ALTERNATIVE 3A PROPOSED COSTS		
Start-Up, Mobilization, Security, & SW3P Items		$74,288
Emergency Spillway Dirt Work Items		$511,250
FM 3122 Road Renovation Items		$162,500
Design Fees (Survey, Geotech, Engineering, etc.)		$132,206
CONTINGENCY	**20%**	$176,048.63
TOTAL:		**$1,056,000**

ALTERNATIVE 3B PROPOSED COSTS		
Start-Up, Mobilization, Security, & SW3P Items		$69,150
Emergency Spillway Dirt Work Items		$502,500
FM 3122 Road Renovation Items		$0
Design Fees (Survey, Geotech, Engineering, etc.)		$105,748
CONTINGENCY	**20%**	$135,479.50
TOTAL		**$813,000**

The cost tables in Table 51 above help to provide a summary of the overall cost of each renovation option. The totals are estimated based on the four categories shown. The "START-UP, MOBILIZATION, SECURITY, & SW3P ITEMS" estimates the cost of the necessary set up (i.e. fences, stabilized entrance ways, and total mobilization). The "EMERGENCY SPILLWAY DIRT WORK ITEMS" calculates the cost based on the desired method for movement of the excess dirt. As shown above, the discrepancies within this category comes from the alternative to keep the dirt inside the emergency spillway corridor instead of being hauled off-site. The "FM 3122 ROAD RENOVATION ITEMS" estimates the cost of lowering the FM 3122 Road to the elevation specified in the original 1966 design drawings. Lastly, the "DESIGN FEES (SURVEY, GEOTECH, ENGINEERING, ETC.)" portion estimates the cost for engineering designs, necessary surveys, engineering testing, and construction management. The totals are calculated from summing the four categories, which help to give an idea of the price difference of each renovation alternative.

8.0 SUMMARY OF RESULTS AND CONCLUSION

8.1 Summary of Results

The results acquired through hydraulic modeling show that the three alternative options provide a viable solution to the Emergency Spillway restoration. Shown in Table 52 below is the time stamps by the hour correlated with the Water Surface Elevation. At the peak inflow timestamp the elevations of the three restoration alternatives are lower than that of the existing model. While the differences may not seem to be substantial, the Damage Curves from Section 7.0 illustrate the increase in damage that can occur due to even a slight increase in WSE.

Each restoration surface comes with strengths and weaknesses generally associated with the Damage Cost savings and the overall cost of renovation. The Damage cost analysis and renovation expenses of the two renovated surfaces (3A and 3B) showed that surface 3A saved the most in both Damage Cost (excluding Alt. 1 Existing) and renovation expenses. The discrepancies between Damage Cost and Renovation expenses found within this report must be weighed according to the desired outcome of the renovation along with budgetary constraints.

Table 52: Timestep vs. Water Surface Elevation (ft)

Timestep	Water Surface Elevation (ft)				Notes
	Alternative No. 1 (Existing)	Alternative No. 2 (Design)	Alternative No. 3A (Renovated)	Alternative No. 3B (Renovated)	
0.00	382.8	382.8	382.8	382.8	No Engagement of Emergency Spillway
1.00	384.4	384.4	384.4	384.4	
2.00	386.3	386.3	386.3	386.3	Water Rising
3.00	388.5	388.4	388.5	388.4	
4.00	391.4	391.3	391.3	391.3	
5.00	**392.7**	**392.3**	**392.4**	**392.3**	***Peak Timestep**
6.00	**393.0**	**392.4**	**392.6**	**392.4**	
7.00	392.9	392.1	392.4	392.0	Water Falling
8.00	392.5	391.7	391.9	391.6	
9.00	392.1	391.3	391.6	391.3	

Table 53: Timestep vs. Discharge (cfs)

Timestep	Discharge at FM 3122 (cfs)				Notes
	Alternative No. 1 (Existing)	Alternative No. 2 (Design)	Alternative No. 3A (Renovated)	Alternative No. 3B (Renovated)	
0.00	0	0	0	0	No Engagement of E- Spillway
1.00	0	0	0	0	
2.00	0	682.0	256.8	744.6	Water Rising
3.00	3908.8	9205.2	7967.1	9755.0	
4.00	22196.1	32158.6	29002.7	33196.5	
5.00	**34654.7**	**46360.1**	**42094.3**	**47485.8**	***Peak Timestep**
6.00	**38307.2**	**50432.0**	**45875.7**	**51578.6**	
7.00	36903.9	48876.5	44415.8	50008.1	Water Falling
8.00	33316.3	44874.1	40675.8	45973.3	
9.00	29484.8	40564.3	36663.3	41621.0	

Table 54: Timestep vs. Lakefront Damage ($)

Timestep	Lakefront Damage ($)				Notes
	Alternative No. 1 (Existing)	Alternative No. 2 (Design)	Alternative No. 3A (Renovated)	Alternative No. 3B (Renovated)	
0.00	$535,992	$535,992	$535,992	$535,992	No Engagement of E-Spillway
1.00	$2,128,854	$2,128,854	$2,128,854	$2,128,854	
2.00	$11,479,008	$11,471,273	$11,475,968	$11,471,062	Water Rising
3.00	$24,121,842	$23,976,455	$24,044,669	$23,963,187	
4.00	$29,922,963	$29,706,060	$29,777,240	$29,683,086	
5.00	**$32,390,958**	**$31,660,145**	**$31,903,445**	**$31,586,547**	***Peak Timestep**
6.00	**$33,062,759**	**$31,919,569**	**$32,316,252**	**$31,808,861**	
7.00	$32,798,110	$31,271,151	$31,806,600	$31,123,347	Water Falling
8.00	$32,105,951	$30,518,731	$30,960,402	$30,398,557	
9.00	$31,357,081	$29,816,030	$30,317,978	$29,684,160	

8.2 Benefit Cost Ratio

A Benefit-Cost Ratio (BC-Ratio) is a tool that is often used to help determine if a project is viable and has the potential to offset costs to a group that would be incurred by a future flooding event. It is also a simplification of the overall value of each proposed plan. The ratio takes into account the costs and damage value associated with each alternative in order to better compare the proposals. Below in Table 55 are the calculated BC-Ratios for each of the proposed alternatives.

Table 55: Benefit-Cost Ratio Table on the PMF Scenario

Alternative	OPCC Cost	Damage Difference at Peak Discharge *Timestep = 10.77 hr.*	BC-Ratio
Alternative 1 (Existing)	$0	$0	**0.00**
Alternative 2 (Design)	$1,566,000	$1,104,445	**0.71**
Alternative 3A (Renovated)	$1,056,000	$741,397	**0.70**
Alternative 3B (Renovated)	$813,000	$1,203,963	**1.48**

8.3 Discussion of Risk

The likelihood of a given storm is extremely important when considering the BC-Ratio and concluding on the results of this report. Because the BC-Ratio uses the damage difference during a peak event, the ratio only evaluates the benefit-cost for an event actually occurring. The reality, however, is that an event of significant magnitude is unlikely and should be considered before taking next steps to implement a project. To understand how unlikely this event would be, additional analysis was completed.

The probability of storm events was previously summarized as part of a December 2016 PER, and the PER. The values used in this report and shown in Table 56 below were plotted along with other elevations including the approximate emergency spillway crest, the crest of the dam and the elevation 393 feet that was used to evaluate flow conveyance for scenarios of spillway terrain renovation (Figure 1).

Table 56: Estimated lake levels (revised conditions), probability and event recurrence interval.

Rain Event	Probability	FNI	Revised Conditions (Carollo PER)
2-year	0.50000	379.2	379.1
5-year	0.20000	379.6	379.5
10-year	0.10000	380.0	379.9
25-year	0.04000	380.6	380.5
50-year	0.02000	381.4	381.3
100-year	0.01000	382.3	382.3
350-year	0.00285	N/A	394.7
500-year	0.00200	384.8	384.9
1,000-yare	0.00100	N/A	387.1
5,000-year	0.00020	N/A	390.0

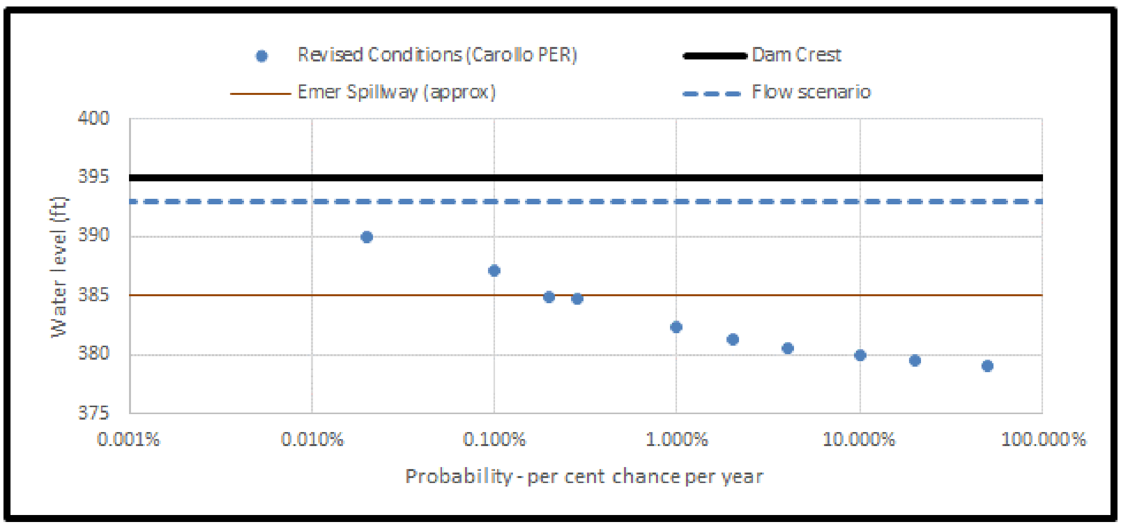


Figure 57: Probability of lake levels with relevant elevations for Emergency Spillway, Dam Crest and hydraulic model scenario for evaluating flow conditions with renovated terrains.

Probability calculations for storm events are most accurate for recurrence intervals on par with records of available data. For example, a 1% chance event (approximately 100-year recurrence interval) can be calculated with accepted level of confidence based upon 100 years of historical data. For areas having only 20 or 40 years of historical data available, hydrologists have developed methods to calculate less frequent events (e.g., the 1% annual chance 100-year event) based in part on proximity to adjacent watersheds with significant data and on regional characteristics. However, as calculated probabilities stray farther below 1% annual chance (or, recurrence interval exceeds 100 years), less confidence can be expected in the calculated result. For this reason, it is uncommon to calculate annual probabilities below 0.2% (recurrence intervals of 500-years).

Water levels and probabilities of interest for this project are less frequent than the 0.2% annual chance (i.e., 500-year event); therefore, estimates of probability are approximate. A rough statistical approach was used to estimate the probability of the 393 foot lake level event. The approach was taken to estimate a low and high value based upon trendlines developed from existing probability calculations (Table 1). A trendline developed from all of the existing probability calculations is shown in blue in Figure 58. Because the probability dots between 1% (100-year) and 0.02% (5,000-year) exhibit a slightly different trend than other events, a second trendline was developed and shown in red in Figure 2. Extrapolating the trendlines of probability results in a calculated probability of between 0.005% annual chance (20,000-year) and 0.001% annual chance (100,000-year) (Table 59).

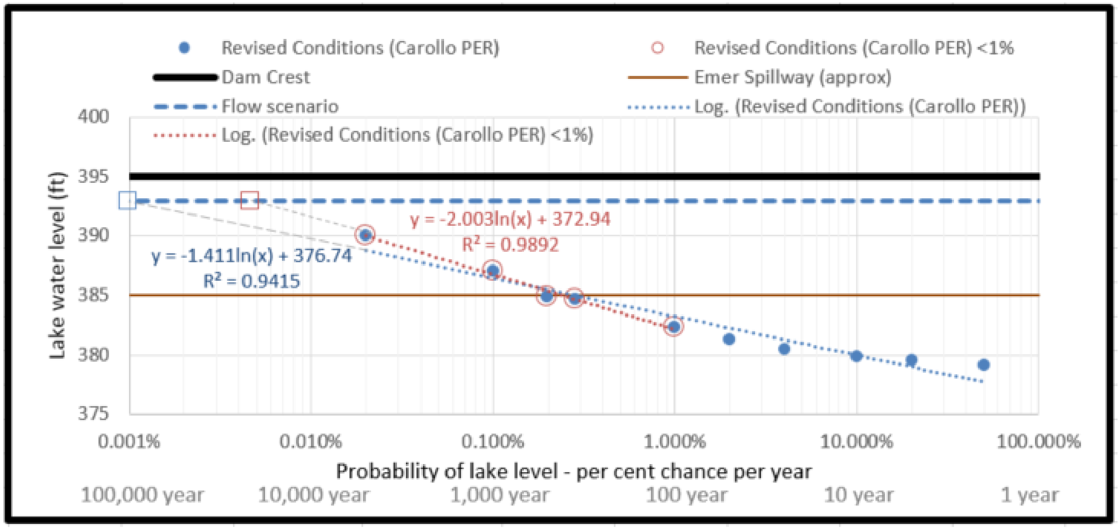


Figure 58: Probability of lake levels with relevant elevations and trendlines.

Table 59: Range of trendline-estimated annual probability of 393 ft lake level.

	Lake level with 2ft Freeboard (ft)	Possible Estimated Event Interval (year)	Calculated Possible Annual Chance Probability (percent)	Trend equation
Trend <1% (Red)	393	22,359	0.0045%	y = -2.003ln(x) + 372.94
Trend all (Blue)	393	101,088	0.0010%	y = -1.411ln(x) + 376.74
Level of uncertainty		High	High	High

While the available information may indicate an annual probability of these events can be calculated, it is important to understand that there is uncertainty not only in the extrapolation, but also in the input data. The input data used for this analysis are themselves calculated probability estimates, and this compounds uncertainty in extrapolating the trendlines.

The safest way to describe the probability of Lake Cypress Springs water level reaching 393 feet is by accurately stating that the probability exceeds both events having 0.1% annual chance (1,000-year recurrence interval) and 0.02% annual chance (5,000-year recurrent interval).

In summary, although the level of uncertainty is high, the trendline predictions showcase that the likelihood of LCS reaching 393' msl is somewhere between a 22,000-year and a 101,000-year storm event.

8.4 Other Considerations

8.4.1 Environmental Considerations

Arroyo Environmental (Arroyo, a subconsultant that has worked on other FCWD projects, has indicated that there is the possibility of wetlands developed in the emergency spillway corridor. Therefore, an environmental survey of the emergency spillway is recommended prior to excavation, if Alternative 2, 3A, or 3B are to be implemented and moved into a design phase.

Carollo recommends that FCWD consult with an environmental consultant prior to a design phase to understand the implications of restoration of the emergency spillway.

Arroyo has provided a quote to do this work, provided in Appendix D: Arroyo Scope of Work.

8.4.2 Dam Operations and Maintenance Manual

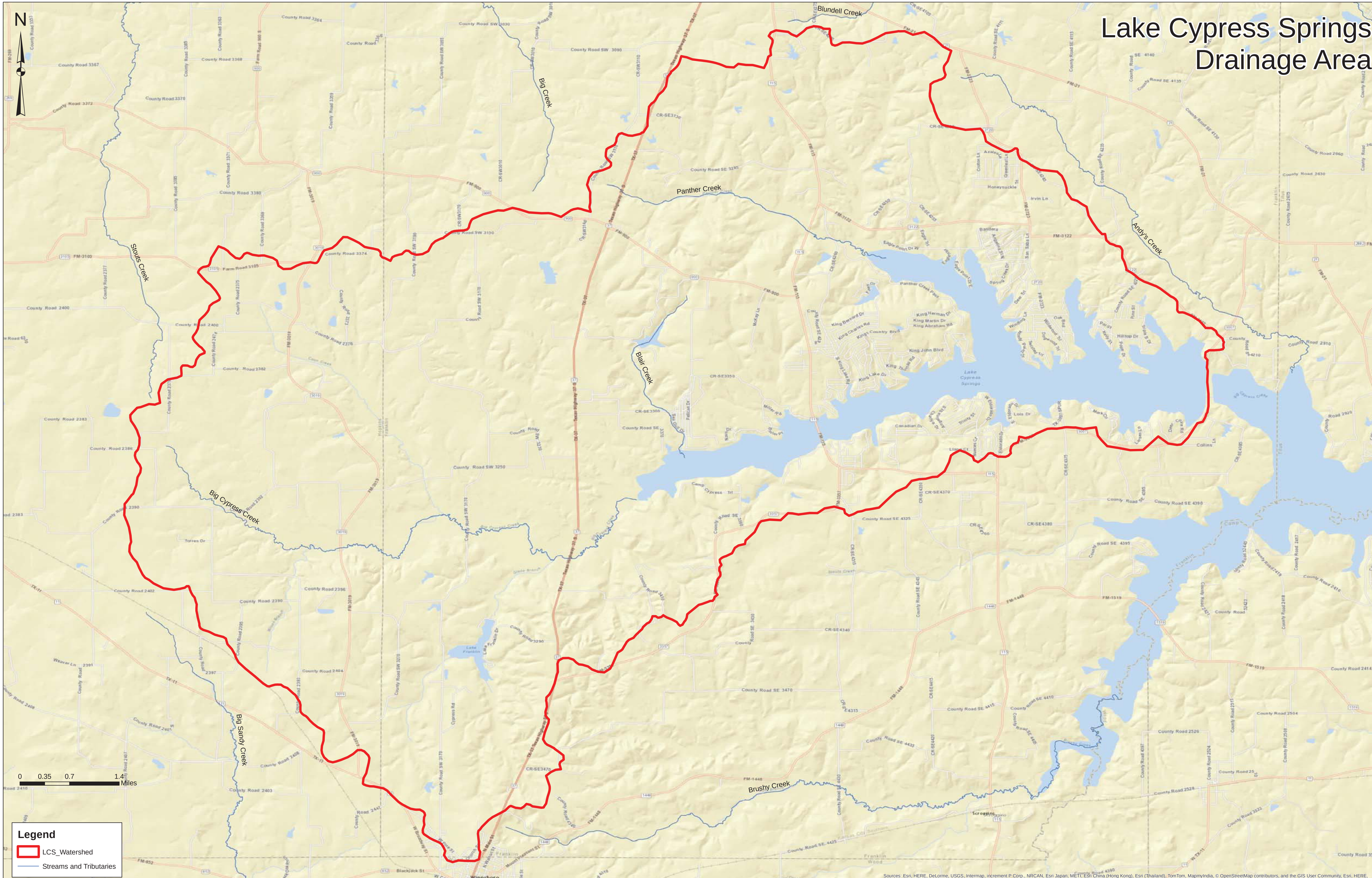
Section 5.2.2 of the Dam and Operations Maintenance Manual for the LCS Dam indicates occasional mowing of the emergency spillway will be necessary. A shorter grass cover provides an ideal surface to protect against erosion, prevents harborage for borrowing animals, and also allows for easier detection of incipient problems. Additionally, the hydraulic modeling in this report (Section 5.9) indicates that mowing can have significant effect on hydraulic conveyance of water down the emergency spillway. The extracted pages from the Dam Operations and Maintenance Manual can be found in Appendix E: Extracted Pages from Dam Operations Manual

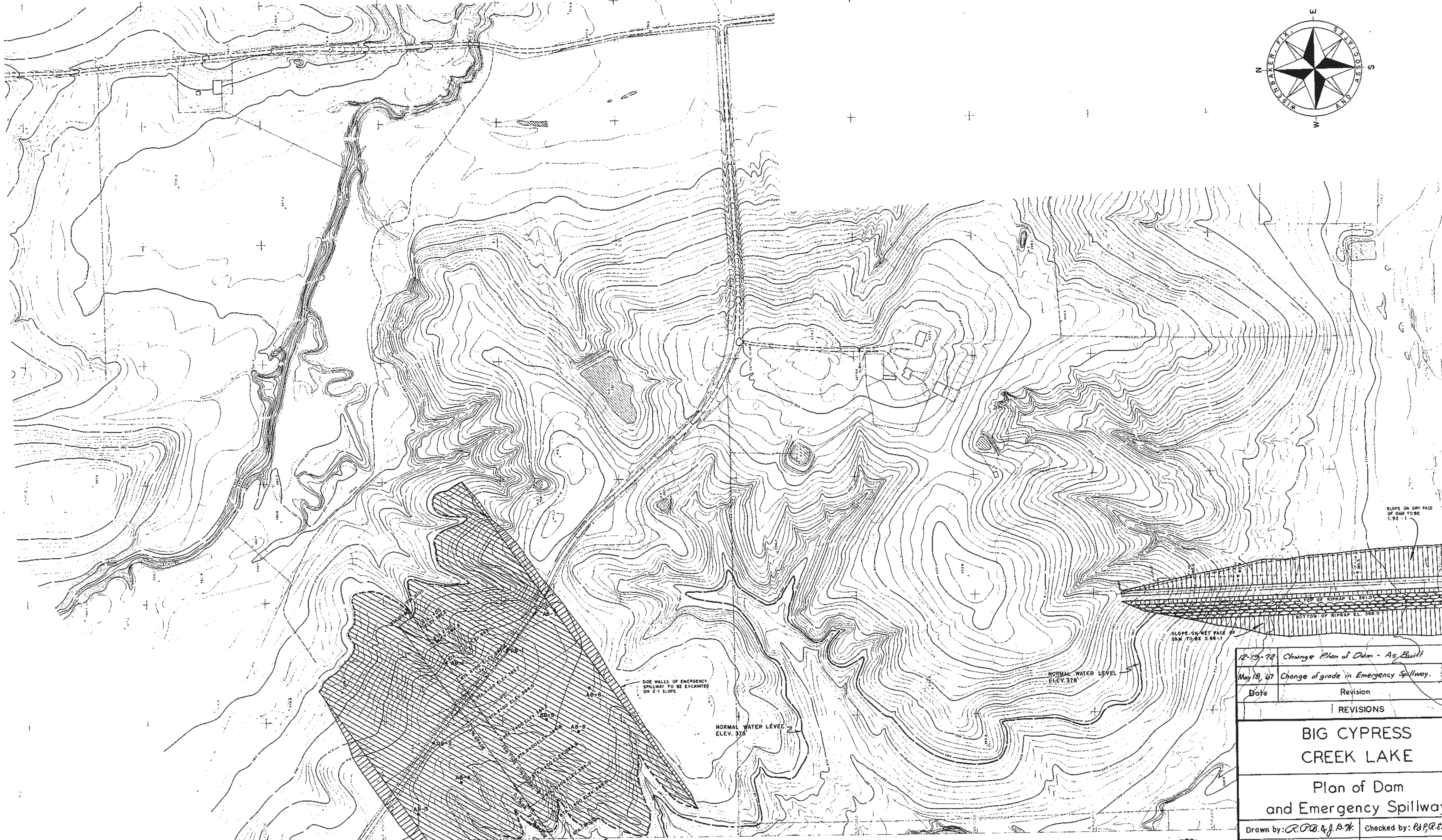
Carollo recommends that using the Emergency Spillway for agricultural practices (primarily the growing of hay) should be discontinued.

8.5 Conclusion

In conclusion, Carollo has offered three hydraulically capable alternatives to restoring the existing condition hydraulic conveyance of the emergency spillway. Each surface comes with an explanation of the data used to create the model and generalized details as to what the restoration process would involve. Additionally, Carollo has produced graphs and tables to illustrate the Damage Cost benefits along with the renovation expenses of each surface.

APPENDIX A
MAPS


Lake Cypress Springs
Drainage Area
N
Legend
LCS_Watershed
Streams and Tributaries
0
0.35
0.7
1.4
Miles
Blundell Creek
Big Creek
Panther Creek
Stouts Creek
Blair Creek
Andy's Creek
Big Cypress Creek
Big Sandy Creek
Brushy Creek
Lake Cypress Springs
Winnsboro
Scroggins
Franklin
Wood
Sources: Esri, HERE, DeLorme, USGS, Intermap, increment P Corp., NRCAN, Esri Japan, METI, Esri China (Hong Kong), Esri (Thailand), TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community, Esri, HERE, DeLorme, MapmyIndia, © OpenStreetMap contributors, and the GIS user community



See sheet no. 5R for profile of spillway.

Note: Elevations are based on datum plane of mean sea level.

Date	Revision	By
12-19-72	Change Plan of Dam - As Built	G.G.C.
May 18, '67	Change of grade in Emergency Spillway.	J.D.H.

REVISIONS

STATE OF TEXAS — PAT D. dePAMPHILIS — 11167 — REGISTERED PROFESSIONAL ENGINEER

STATE OF TEXAS — WALTER F. HICKS, JR. — 11170 — REGISTERED PROFESSIONAL ENGINEER

BIG CYPRESS CREEK LAKE

Plan of Dam and Emergency Spillway

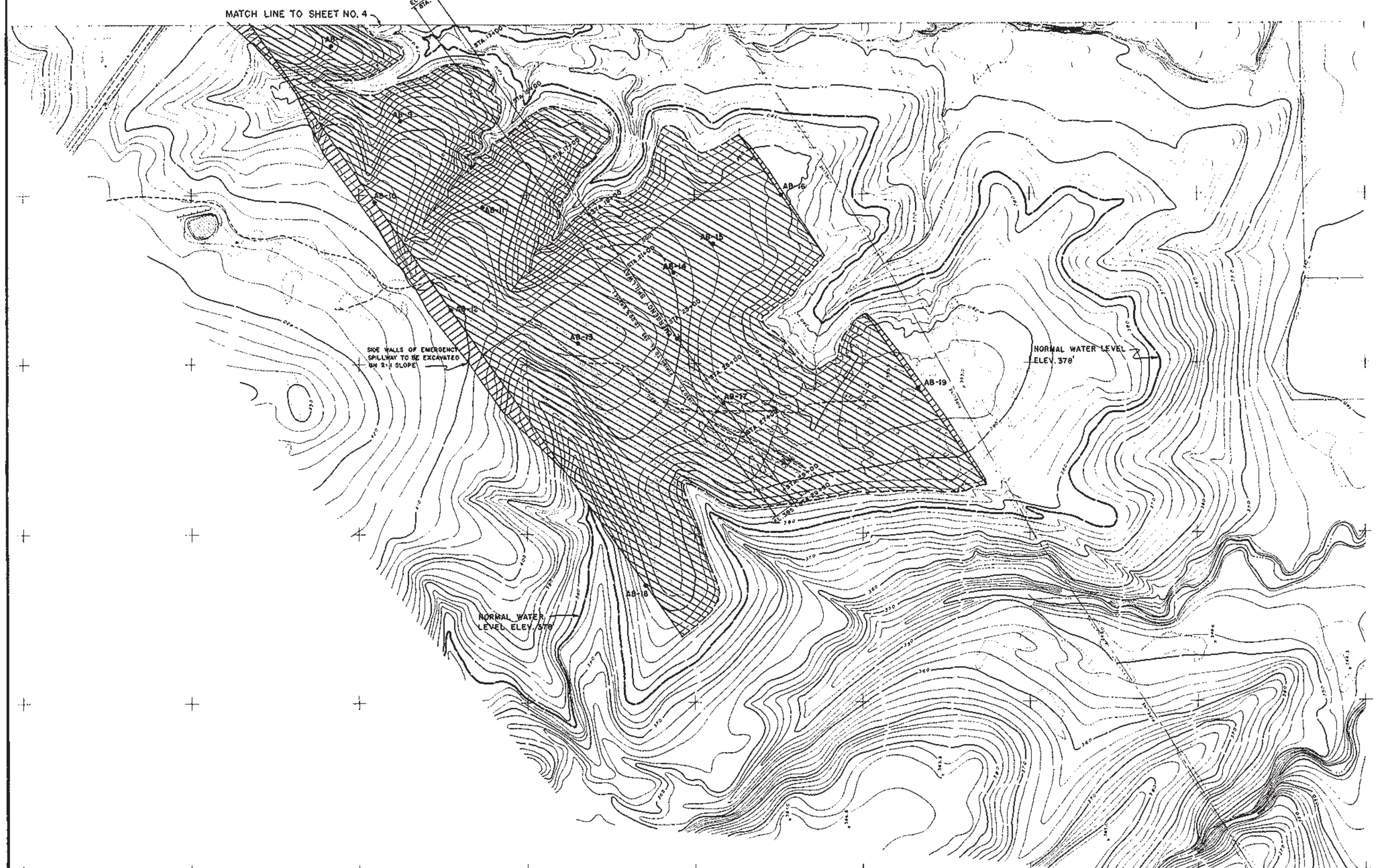
Drawn by: R.P.B. & J.B.W.	Checked by: PdP, R.E.B., W.F.H.
Job No.: 854	Date: March 14, 1967
Scale: 1 Inch = 200 Feet	

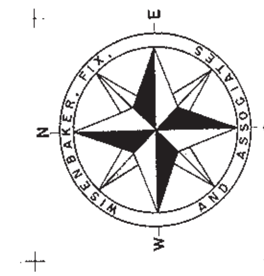
WISENBAKER, FIX, AND ASSOCIATES

Consulting Engineers

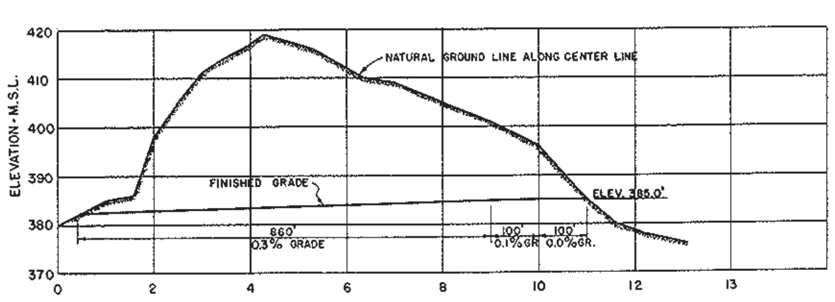
Tyler, Texas

Sheet No. 4R of 26 Sheets





NOTE: Elevations are based on datum of mean sea level.



PROFILE OF EMERGENCY SPILLWAY
Scale: 1" = 20' Vert., 1" = 200' Horiz.

Date	Revision	By
May 18, '67	Profile of Emergency Spillway added.	G.D.H.

REVISIONS

BIG CYPRESS CREEK LAKE

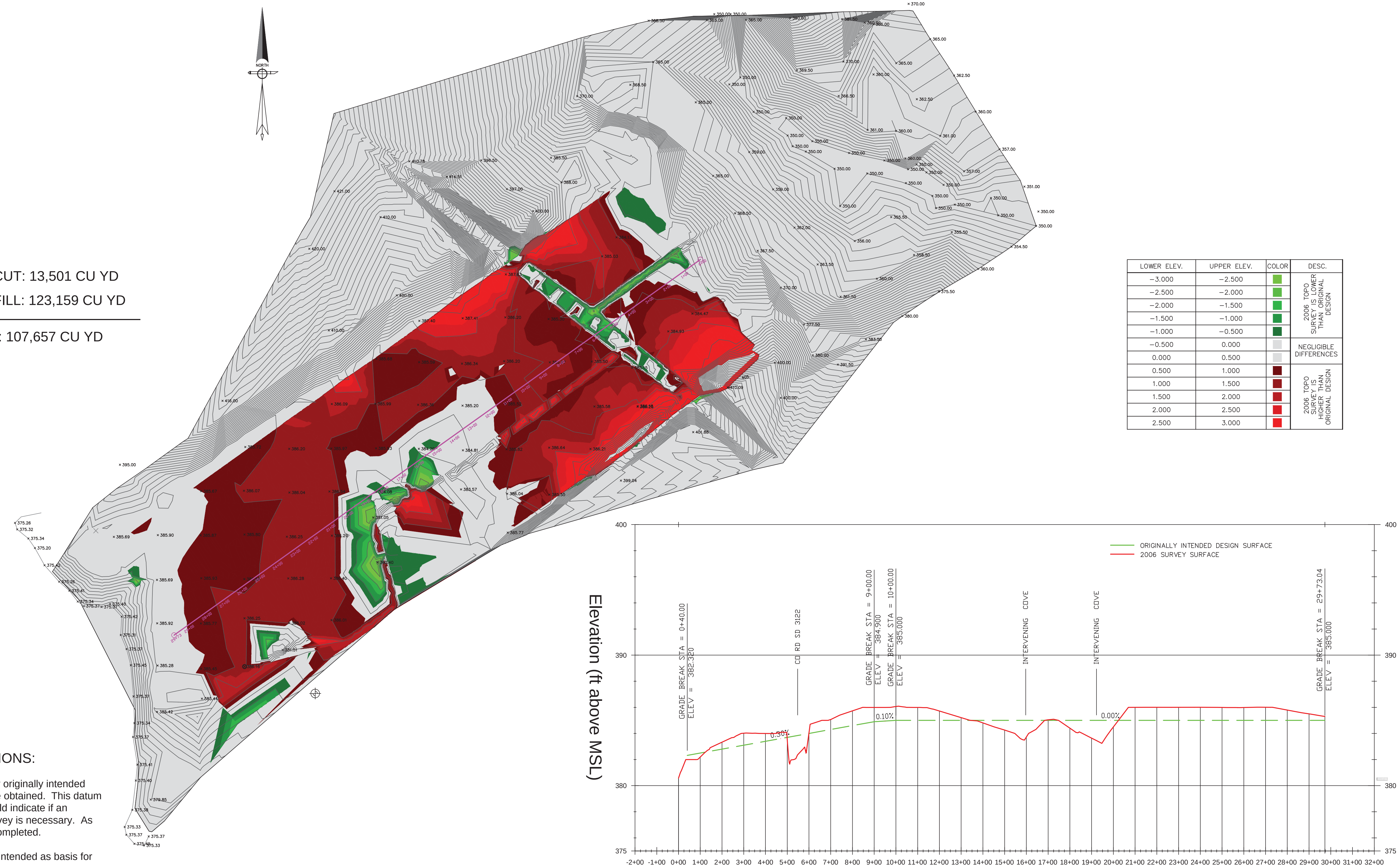
Plan of Emergency Spillway

Drawn by: R.O.B. & G.D.H.
Checked by: P.D.P., R.E.O., & W.F.H.
Job No.: 854
Date: March 14, 1967
Scale: 1 Inch = 200 Feet

WISENBAKER, FIX, AND ASSOCIATES
Consulting Engineers
Tyler, Texas

Sheet No. 5R of 26 Sheets

Prepared for:
Franklin County Water District
P.O. Box 559
Mount Vernon, Texas 75457



GROSS CUT: 13,501 CU YD

GROSS FILL: 123,159 CU YD

NET FILL: 107,657 CU YD

LOWER ELEV.	UPPER ELEV.	COLOR	DESC.
-3.000	-2.500		2006 TOPO SURVEY IS LOWER THAN ORIGINAL DESIGN
-2.500	-2.000		
-2.000	-1.500		
-1.500	-1.000		
-1.000	-0.500		
-0.500	0.000		NEGLIGIBLE DIFFERENCES
0.000	0.500		
0.500	1.000		2006 TOPO SURVEY IS HIGHER THAN ORIGINAL DESIGN
1.000	1.500		
1.500	2.000		
2.000	2.500		
2.500	3.000		

NOTES & ASSUMPTIONS:

1. Vertical elevation datum for originally intended design surface could not be obtained. This datum is important because it would indicate if an adjustment to the 2006 survey is necessary. As such, no adjustment was completed.

2. Not for construction. Only intended as basis for further discussion.

REV	DATE	BY	DESCRIPTION

DESIGNED PWB
DRAWN PWB
CHECKED TS / DH
DATE FEBRUARY 2016

STATE OF TEXAS
PHILIP W. BULLOCK JR.
114841
LICENSED
PROFESSIONAL ENGINEER

carollo®

FRANKLIN COUNTY WATER DISTRICT (FCWD)

LAKE CYPRESS SPRINGS

ORIGINALLY INTENDED DESIGN VS. 2006 SURVEY

JOB NO. 10070A.00

DRAWING NO. 1 OF 1

SHEET NO. 1 OF 1

LEASE AGREEMENT

THE STATE OF TEXAS	*	
	*	
	*	KNOW ALL MEN BY THESE PRESENTS
	*	
COUNTY OF FRANKLIN	*	

This Lease Agreement is made and entered into by and between FRANKLIN COUNTY WATER DISTRICT, hereinafter called LESSOR, and B.F. HICKS, AS EXCHANGE TRUSTEE FOR NAUS, LTD., hereinafter called LESSEE. Wherever the term LESSOR is used herein it shall mean Franklin County Water District, or any successor assigns; and wherever the term LESSEE is used it shall mean the original lessee, his assigns, heirs or successors. This agreement shall be binding on Lessor and Lessee as the terms are used. The real property the subject of this lease (hereinafter referred to as the "REAL PROPERTY") is a 13.406 acre tract in the William McNeese Survey, Abstract No. 335, Franklin County, Texas, fully described by metes and bounds in Exhibit A attached hereto and made a part hereof for all purposes.

WITNESSETH:

1.

Subject to the covenants, conditions, reservations, restrictions, rules, and regulations herein contained or referred to, LESSOR hereby leases unto LESSEE surface only of the REAL PROPERTY described above for a term of ninety-nine (99) years from and after the effective date hereof which is December 17, 1999, so long as LESSEE, but subject to other terms and conditions herein, pays to LESSOR at its principal office in Mount Vernon, Texas, an annual rental as herein set out.

The bonus payment of this lease is FIVE HUNDRED FORTY THOUSAND DOLLARS ($540,000.00), which will be paid at the execution of this Lease Agreement.

The rental on the property described above shall be $60.00 per acre per annum. The first rental payment shall be made upon execution of this agreement and thereafter the rental shall be due on December 17th of each consecutive year thereafter during the term of this lease.

Upon Lessee's failure to pay any rental when due, after notice in writing delivered in person or by certified mail, Lessee shall have thirty (30) days to cure such default, but on and after said 30th day, this lease shall terminate by reason of non-payment of any rental sum, and Lessee hereby agrees to turn possession of said leased premises back to Lessor, its agents, or representatives or any successor or assigns. Lessor agrees to give written notice of its intention to terminate the lease because of non-payment of any rental sum at least sixty (60) days prior to the date of termination to the post office address of Lessee shown in this instrument, or to such other address Lessee shall designate in writing to Lessor.

LESSEE shall be solely responsible for payment of past and future ad valorem taxes assessed against the property.

2.

Subject to the covenants, conditions, reservations, restrictions, rules, and regulations herein contained or referred to, LESSOR does hereby grant, bargain, sell, transfer, and convey to LESSEE, its successors and assigns, for the purpose of ingress, egress, and utility access, a non-exclusive right of way (hereinafter referred to as the "EASEMENT") over the fifty-foot wide tract or parcel of land situated in the William McNeese Survey, Abstract No. 335, Franklin County, Texas, fully described by metes and bounds in Exhibit B attached hereto and made a part hereof for all purposes, for the benefit of and as an easement appurtenant to the REAL PROPERTY. LESSOR and LESSEE agree that this EASEMENT shall run concurrently with the term set forth in this Lease Agreement and shall be further conditioned on the terms and conditions contained herein.

LESSEE shall be solely responsible for the construction and maintenance of any roadway. LESSEE acknowledges that the EASEMENT is located on the spillway of Cypress Springs Lake, operated by LESSOR. Accordingly, LESSEE shall not construct a roadway or other improvement on the EASEMENT above the elevation of the spillway or which could otherwise interfere with the operation of the spillway. This EASEMENT is conditioned on LESSEE's reasonable exercise for the benefit of the REAL PROPERTY, and in the event of use for nondominant purposes, or use by means otherwise injurious to the spillway, LESSOR is entitled to extinguish the EASEMENT.

3.

The Board of Directors of said District has officially found that this lease will not interfere with the use of the other property of the District and that the monies received by it as bonus and rentals hereunder are to be used for the operation and maintenance of the entire Franklin County Dam & Reservoir Project. LESSEE agrees that it will make such use of the leased premises as is not inconsistent with the use of such lands for the protection, maintenance, and operation of the water supply features of the project.

4.

LESSEE, its successor, heirs or assigns, may upon written permission of LESSOR assign or sublet the leased premises but in any such assignment or sublease provision shall be made so that the assignee or sublessee shall be bound by all the terms and conditions of this original lease, as well as any covenants, conditions and restrictions affecting the leased premises which are filed of record in the office of the County Clerk of Franklin County, Texas, and any rules or regulations of the Franklin County Water District now existing or hereafter adopted.

5.

It is expressly understood and agreed by Lessee as a part of the condition for the execution of this lease that at all times Lessee shall obey and comply with the rules and regulations of Lessor, including zoning and use regulations then in effect, and that a breach or non-compliance therewith shall operate as a forfeiture of all rights granted to Lessee herein; provided, however, if Lessee shall cease and desist from such breach or violation of the rules and regulations of Lessor within thirty (30) days of written notification by Lessor of such violation, then and in such event, no forfeiture of Lessee's rights granted herein shall occur and lease shall continue in full force and effect.

It is agreed and understood by the parties hereto that the demised property has been zoned SINGLE FAMILY RESIDENTIAL at this time.

6.

LESSOR reserves the right to enter upon said leased premises at any and all reasonable times for the purpose of inspecting the same in order to determine whether LESSEE is complying with the provisions and obligations of this lease and in order to perform any obligations of this lease and in order to perform any obligations or duty which LESSOR may have to the public in general, and in order to enforce and to assist in the enforcement of all valid state laws and regulations, now or hereafter to be in force, governing its operations as a political subdivision. LESSOR has the right to enter upon any of the property of Lessee to use any roads for the purposes of conducting its duties, enforcing its rules and regulations, and for any other matter incident to this lease.

7.

LESSEE further agrees to hold LESSOR harmless from and against any and all claims, damages, suits or causes of action arising after the effective date hereof, including all costs of defense and attorney's fees incurred by LESSOR in such connection, and any orders, decrees or judgments which may be entered therein, brought as a result of alleged breaches of contract or alleged tortuous conduct or from high water or flooding or otherwise or as a result of alleged damages resulting from an injury to person or property sustained in or about said premises, or in or about any sidewalks or streets in front of or appurtenant thereto by any person or party whatsoever.

8.

LESSEE shall be entitled to remove at Lessee's expense all improvements situated and installed by Lessee on the hereinabove described property for a period of one hundred twenty (120) days after any termination of this lease, or the property shall then belong to the District, provided Lessee is not in arrears in the payment of rental stipulated. It is further expressly understood and agreed that Lessor shall have and is hereby given an express landlord's lien on all improvements and fixtures and/or merchandise installed, constructed or located by Lessee on the hereinabove described premises to secure the payment of the rental provided for above. Upon payment of said rental and release of landlord's lien by Lessor, Lessee is given the same rights of removal of improvements as set out above.

9.

Any lot assigned by the registered owner must be re-registered with the District by furnishing its office with a copy of the conveyance or assignment, together with such transfer fee as is in effect at the time of the transfer. Should the rental due on said lot become delinquent, the owner whose name appears on the register of the Water District shall be notified of the delinquency and said lot owner shall have a period of thirty (30) days in which to make payment.

Any lessee who seeks a loan for either the purchase of said lot or the erection of improvements shall register the appropriate loan information with the District for which such loan registration fee as is in effect at the time of registration shall be paid to the District, whereupon the District obligates itself to execute an agreement with the lender to notify lender in writing of any default as to the rental or the violation of any covenant so that the lender agency shall have the right within thirty (30) days after said notice to pay the delinquent rental theretofore assigned to said lot and/or to correct the covenant violation, if any.

10.

This agreement is to be performed in Franklin County, Texas, and shall be binding on the undersigned, their respective heirs, successor, legal representatives or assigns.

Lessor's and Lessee's post office addresses are as follows:
LESSOR: Post Office Box 559, Mount Vernon, Texas 75457
LESSEE: Post Office Box 985, Mount Vernon, Texas 75457

The foregoing is executed in duplicate counterparts, each having the full force and effect of any original, on this 17th day of December, 1999.

FRANKLIN COUNTY WATER DISTRICT

BY ______________________
Kenneth Jaggers, President
Board of Directors, LESSOR

____
B.F. Hicks, LESSEE

ATTEST:

____

LYNN SWANNER, INC.
Engineering and Professional
Land Surveying Since 19

Route 1 Box 10090
Winnsboro, Texas 75494
903-365-2379

FIELD NOTES FOR 13.406 ACRES
McNEESE SURVEY - FRANKLIN COUNTY, TEXAS

All that certain tract or parcel of land situated in the William McNeese Survey, Abstract No. 335, Franklin County, Texas; being a part of that certain 149.372 acre tract described in Deed to the Franklin County Water District, recorded in Volume 92, Page 29, Deed Records of Franklin County, Texas; and being more particularly described as follows:

BEGINNING at a 1/2 inch iron rod set on the normal water line of Lake Cypress Springs and being S 62° 13' 26" W - 298.98 feet from the Northeast corner of said 149.372 acre tract and being S 18° 59' 53" W - 2203.41 feet from the Southernmost Northeast corner of a 137.031 acre tract described in Deed to said District, recorded in Volume 91, Page 338 of said Deed Records;

THENCE with said normal water line as follows: S 4° 57' 47" W - 93.79 feet, S 14 ° 03" 43" W - 101.34 feet, S 7° 00' 27" W - 186.04 feet, S 89° 25' 05" W - 81.56 feet, S 23° 09' 21" W - 25.67 feet, S 84° 46' 09" W - 29.17 feet, N 66° 34' 00" W - 131.34 feet, S 24° 59' 04" W - 67.39 feet, N 84° 39' 08" W - 72.49 feet, N 45° 25' 25" W - 120.63 feet, S 30° 54' 51" W - 71.77 feet, S 9° 04' 19" W - 71.64 feet, S 11° 22' 32" E - 26.01 feet, S 32° 59' 39" E - 28.04 feet, S 32° 43' 09" E - 99.58 feet, S 64° 03' 24" E - 281.16 feet, S 60° 37' 54" W - 148.75 feet, S 21° 49' 07" W - 70.26 feet, S 59° 46' 18" E - 62.21 feet, S 50° 47' 08" W - 103.32 feet, N 88° 06' 50" W - 60.98 feet, S 51° 40' 40" W - 277.13 feet, S 64° 09' 33" W - 156.45 feet, N 72° 01' 27" W - 90.34 feet, N 30° 07' 43" W - 131.60 feet, N 50° 25' 58" W - 115.54 feet, N 69° 50' 37" W - 75.76 feet, S 84° 58' 10" W - 96.24 feet, and N 2° 11' 39" E - 227.84 feet to a 1/2 inch iron rod set for corner;

THENCE in an Easterly direction as follows: N 53° 34' 27" E - 685.89 feet, N 59° 14' 56" E - 267.26 feet, S 66° 23' 49" E - 86.69 feet, S 72° 11' 18" E - 71.08 feet, and N 49° 45' 11" E - 361.82 feet to the PLACE OF BEGINNING containing 13.406 acres.

NOTE: all 1/2 inch iron rods set with surveyor's cap marked *SWANNER*.

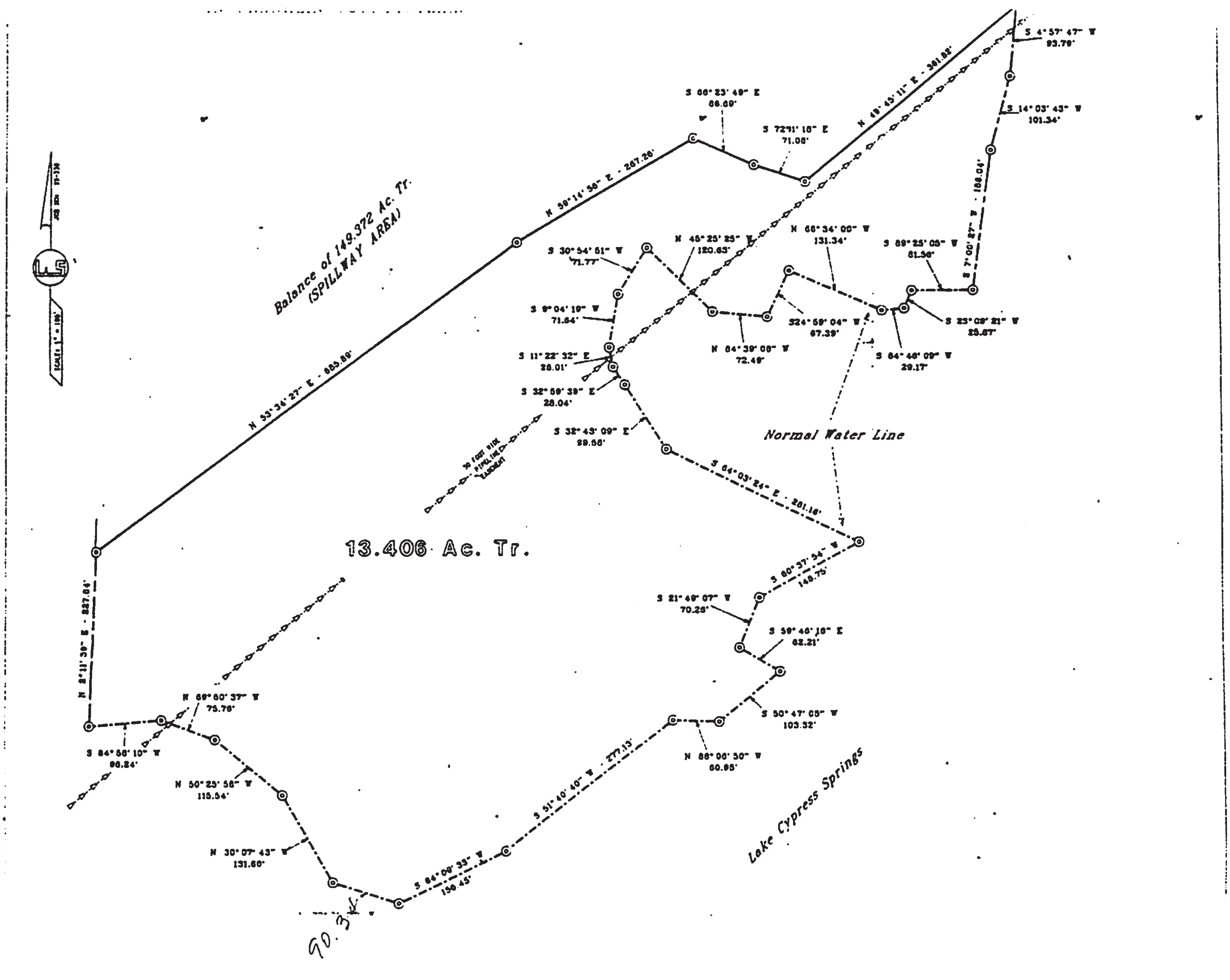
I, Lynn Swanner, Registered Professional Land Surveyor, do hereby certify that this survey was made on the ground under my supervision. See "SURVEY PLAT FOR 13.406 ACRES" of same date attached for a visual reference.

Dated this the 6th day of August, 1999.

Signed: [signature]
Lynn Swanner, R.P.L.S. No. 3806

fcwd

Exhibit A,
Page 1



2385' Wf

Exhibit A
Page 2

LYNN SWANNER, INC.
Engineering and Professional
Land Surveying Since 1972

Route 1 Box 10090
Winnsboro, Texas 75494
903-365-2379

For: Dr. Naus

FIELD NOTES FOR AN ACCESS EASEMENT
McNEESE SURVEY – FRANKLIN COUNTY, TEXAS

All that certain tract or parcel of land situated in the William McNeese Survey, Abstract No. 335, in Franklin County, Texas; being a part of that certain 137.031 acre tract described in Deed to the Franklin County Water District, recorded in Volume 91, Page 338, Deed Records of Franklin County, Texas; being a part of that certain 149.372 acre tract described in Deed to said Water District, recorded in Volume 92, Page 29 of said Records; being a part of that certain 94.307 acre tract described in Deed to said Water District, recorded in Volume 91, Page 422 of said Records; and the center line of a 50.0 foot wide Access Easement being more particularly described as follows:

BEGINNING at a point on the West right-of-way line of FM Highway No. 3122 (being 70.0 feet from the center line), and being N 15° 12' 17" E - 1037.58 feet from the Southwest corner of said 94.307 acre tract and the Southeast corner of said 137.031 acre tract;

THENCE in a Westerly direction along first said center line as follows: S 53° 25' 54" W - 933.66 feet, S 60° 17' 39" W - 423.66 feet, S 15° 24' 35" E - 410.57 feet, S 49° 45' 11" W - 288.37 feet, N 72° 11' 18" W - 54.61 feet, N 66° 23' 49" W - 99.38 feet, S 59° 14' 56" W - 282.66 feet, and S 53° 34' 27" W - 665.92 feet to a point for the end of said Access Easement situated on the normal water line of Lake Cypress Springs and the Northwest corner of a 13.406 acre tract bears S 2° 11' 41" W - 32.00 feet.

NOTE: Bearings based on the Southernmost East line of a 94.307 acre tract described in Volume 91, Page 422, Deed Records of Franklin County, Texas.

I, Lynn Swanner, Registered Professional Land Surveyor, do hereby certify that this survey was made on the ground under my supervision. See "SURVEY PLAT FOR AN ACCESS EASEMENT" of same date attached for a visual reference.

Dated this the 18th day of November, 1999.

Signed: Lynn Swanner
Lynn Swanner, R.P.L.S. No. 3806

STATE OF TEXAS
REGISTERED
LYNN SWANNER
3806
PROFESSIONAL
LAND SURVEYOR

99-338B

Exhibit B,
Page 1

APPENDIX B
VOLUMETRIC SURVEY

Volumetric and Sedimentation Survey of LAKE CYPRESS SPRINGS

July 2007 Survey

Prepared by:

The Texas Water Development Board

October 2008

Texas Water Development Board

J. Kevin Ward, Executive Administrator

Prepared for:

Franklin County Water District

With Support Provided by:

U.S. Army Corps of Engineers, Fort Worth District

This report was prepared by staff of the Surface Water Resources Division:

Barney Austin, Ph.D., P.E.
Jordan Furnans, Ph.D., P.E.
Jason Kemp, Team Leader
Randall Burns
Tony Connell
Holly Weyant

Published and Distributed by the
Texas Water Development Board
P.O. Box 13231
Austin, TX 78711-3231

Executive Summary

In 2007, the Texas Water Development Board entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, for the purpose of performing a volumetric and sediment survey of Lake Cypress Springs. This survey was performed using a multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder. In addition, sediment core samples were collected in selected locations and were used in interpreting the multi-frequency depth sounder signal returns to derive sediment accumulation estimates.

Franklin County Dam and Lake Cypress Springs are located on Big Cypress Creek in the Cypress River Basin 8 miles southeast of Mount Vernon in Franklin County, Texas. Bathymetric data collection for Lake Cypress Springs occurred on June 21st, June 27th-June 29th, July 10th, and July 11th of 2007, while the water surface elevation ranged between 378.22 feet and 379.42 feet above mean sea level (NGVD29). The conservation pool elevation of Lake Cypress Springs is 378.0 feet above mean sea level (NGVD 29).

The results of the TWDB 2007 Volumetric Survey indicate Lake Cypress Springs has a total reservoir capacity of 66,756 acre-feet and encompasses 3,252 acres at conservation pool elevation (378.0 feet above mean sea level, NGVD29). In 1998 TWDB estimated the capacity of Lake Cypress Springs (at conservation pool elevation) at 67,690 acre-feet.[1] Due to differences in the methodologies used in calculating areas and capacities from this and previous Lake Cypress Springs surveys, comparison of these values is not recommended.[2] The TWDB considers the 2007 survey to be a significant improvement over previous methods and recommends that a similar methodology be used to resurvey Lake Cypress Springs in 10 to 20 years or after a major flood event.

The results of the TWDB 2007 Sediment Survey indicate Lake Cypress Springs has accumulated 3,807 acre-feet of sediment since impoundment in 1970. Based on this measured sediment volume and assuming a constant sediment accumulation rate, Lake Cypress Springs loses approximately 100 acre-feet of capacity per year. The majority of the sediment accumulation has occurred within the main body of the lake, with the thickest deposits in the submerged Big Cypress Creek channel. The maximum sediment thickness observed in Lake Cypress Springs was 7.2 feet.

Table of Contents

List of Tables

List of Figures

Appendices

Lake Cypress Springs General Information

Franklin County Dam and Lake Cypress Springs are located on Big Cypress Creek in the Cypress River Basin 8 miles southeast of Mount Vernon in Franklin County, Texas.[3] (Figure 1) Lake Cypress Springs is maintained and operated by the Franklin County Water District.[4] Construction on Franklin County Dam began in July of 1968, with deliberate impoundment beginning on July 7, 1970. The project was completed on February 15, 1971.[3] Lake Cypress Springs serves mainly as water supply storage for municipal and industrial uses. Additional pertinent data about Franklin County Dam and Lake Cypress Springs can be found in Table 1.

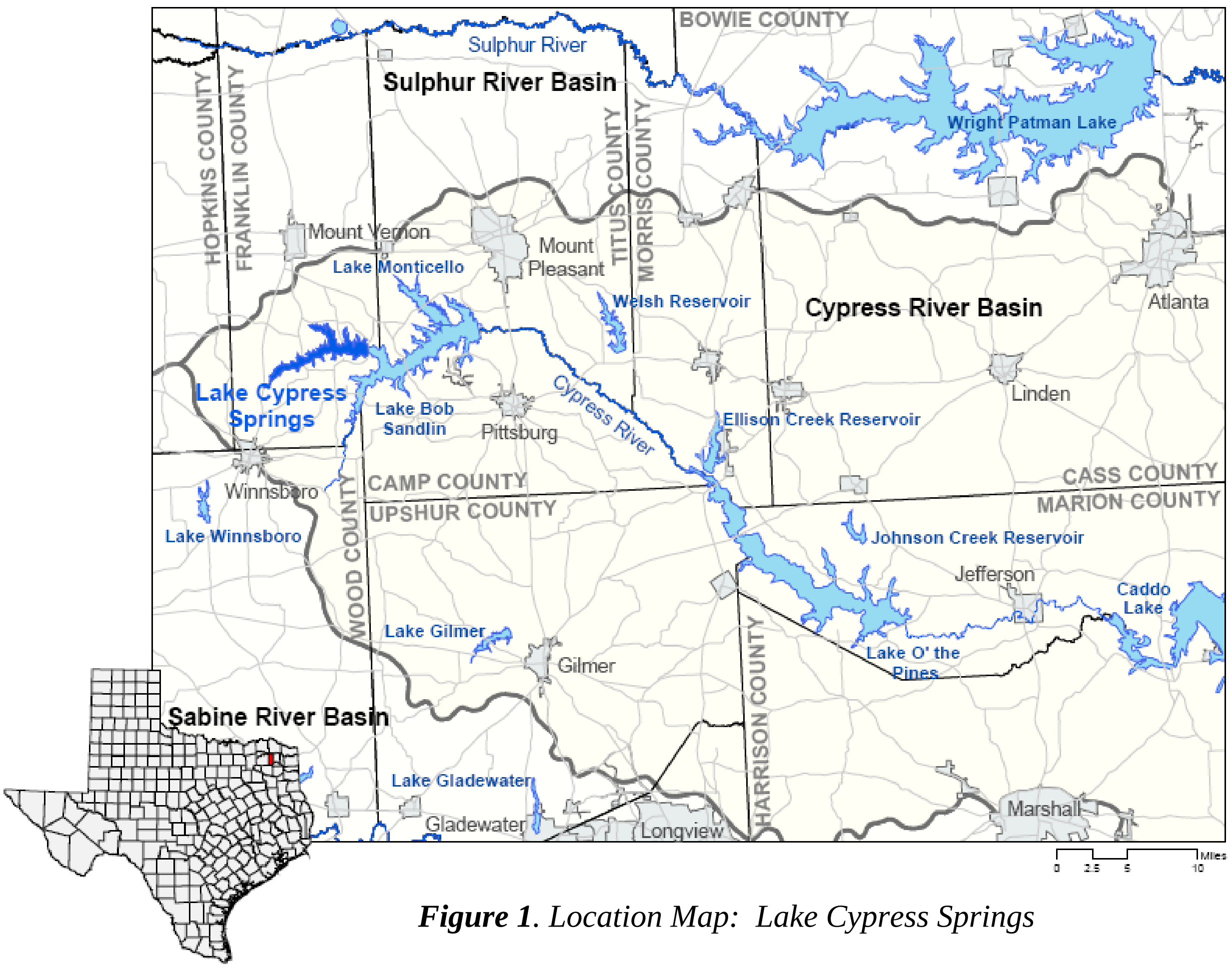


***Figure 1**. Location Map: Lake Cypress Springs*

Table 1. Pertinent Data for Franklin County Dam and Lake Cypress Springs[3]	
Owner	
Franklin County Water District	
Engineer (Design)	
Wisenbaker, Fix, and Associates	
Location of Dam	
On Big Cypress Creek in Franklin County, 8 miles southeast of Mount Vernon	
Drainage Area	
75 square miles	
Dam	
Type	Earthfill
Length	5,230 feet
Maximum Height	74 feet
Top Width	44 feet
Top elevation (varies)	395.0 to 397.0± feet above mean sea level
Spillway (emergency)	
Location	To left of the dam
Type	Excavated and graded area
Crest length	1,000 feet
Crest elevation	385.0 feet above mean sea level (NGVD29)
Spillway (service)	
Location	Right end of main embankment
Type	Rectangular drop inlet, 23 by 23 feet
Control	None
Crest elevation	378.0 feet above mean sea level (NGVD29)
Outlet	Box culvert, 10 by 10 feet
Discharge	To stilling basin
Outlet Works	
Type	Concrete pipe, 18-inch diameter
Invert elevation	317.75 feet above mean sea level (NGVD29)
Control	Duplicate valves with vertical stems
Discharge	To service spillway conduit

Water Rights

The water rights for Lake Cypress Springs have been appropriated to the Franklin County Water District through Certificate of Adjudication No. 04-4560 and its amendments. A brief summary of the certificate and each amendment follows. The complete certificates are on file in the Records Division of the Texas Commission on Environmental Quality.

Certificate of Adjudication No. 04-4560

Issued: October 13, 1986

Authorizes the Franklin County Water District to maintain an existing dam and reservoir (Lake Cypress Springs) and impound therein a maximum of 72,800 acre-feet of water. Franklin County Water District is authorized to divert and use up to 9,300 acre-feet of water per year for municipal purposes, of which 5,000 acre-feet of water may be diverted into the Sabine River Basin and 2,185 acre-feet into the Sulphur River Basin, 5,940 acre-feet of water per year for industrial purposes, and up to 60 acre-feet per year for irrigation purposes. The impounded water may also be used for recreational purposes. The priority dates of the owners' rights are January 31, 1966 for Lake Cypress Springs and the transbasin diversion of 1,000 acre-feet of water directed to the City of Mount Vernon for municipal purposes; July 20, 1970 for the diversion and use of 60 acre-feet of water per year for irrigation purposes, 8,300 acre-feet per year for municipal purposes, of which 4,173 acre-feet per year relates to transbasin diversion, and 5,940 acre-feet per year for industrial purposes; October 6, 1980 for an increase of the diversion rate from 27.0 cubic feet per second to 40.4 cubic feet per second and to transfer 2,012 acre-feet for municipal use from the Cypress Creek Basin to the Sabine River Basin; and April 18, 1983 for the increase of the diversion rate from 40.4 cubic feet per second to 161.5 cubic feet per second.

Amendment to Certificate of Adjudication No. 04-4560A
Granted: December 12, 1989

Authorizes a change in purpose of use of 300 acre-feet of the 5,940 acre-feet of water per annum for industrial use to irrigation use; thereby authorizing the Franklin County Water District to divert and use a maximum of 5,640 acre-feet of water per year for industrial purposes and 360 acre-feet per year for irrigation purposes. The time priority for these diversions remains July 20, 1970.

Amendment to Certificate of Adjudication No. 04-4560B
Granted: June 5, 1998

In lieu of the Franklin County Water District's authorization to divert and use from Lake Cypress Springs a maximum 2,050 acre-feet of water per year for industrial use, 360 acre-feet per year for irrigation use, and 9,300 acre-feet of water per year for municipal purposes (of which 2,185 acre-feet may be used in the Sulphur River Basin), Franklin County Water District is authorized to divert and use a maximum 11,500 acre-feet of water per year for municipal purposes (of which 4,385 acre-feet of water per year may be used in the Sulphur River Basin) and 210 acre-feet of water per year for irrigation purposes.

Volumetric and Sediment Survey of Lake Cypress Springs

Introduction

The Texas Water Development Board's (TWDB) Hydrographic Survey Program was authorized by the state legislature in 1991. The Texas Water Code authorizes TWDB to perform surveys to determine reservoir storage capacity, sedimentation levels, rates of sedimentation, and projected water supply availability.

In 2007, TWDB entered into agreement with the U.S. Army Corps of Engineers, Fort Worth District, for the purpose of performing a volumetric and sediment survey of Lake Cypress Springs. This survey was performed using a single-beam multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder. The 200 kHz return indicates the current bathymetric surface, while the combination of the three frequencies is analyzed for evidence of sediment accumulation throughout the reservoir. Sediment core samples are collected in order to validate the interpretation of the multi-frequency acoustic signals and to verify the identification of the reservoir bathymetric surface at the time of initial impoundment.

Datum

The vertical datum used during this survey is that used by the United States Geological Survey (USGS) for the reservoir elevation gauge USGS 07344484 Lk Cypress Spgs nr Mount Vernon, TX.[5] The datum for this gauge is reported as National Geodetic Vertical Datum 1929 (NGVD29) or mean sea level, thus elevations reported here are in feet above mean sea level. Volume and area calculations in this report are referenced to water levels provided by the USGS gauge. The horizontal datum used for this report is NAD83 State Plane Texas North Central Zone.

TWDB Bathymetric Data Collection

Bathymetric data collection for Lake Cypress Springs occurred on June 21st, June 27th-June 29th, July 10th, and July 11th of 2007, while the water surface elevation ranged between 378.22 feet and 379.42 feet above mean sea level (NGVD29). For data collection, TWDB used a Specialty Devices, Inc., multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder integrated with Differential Global Positioning System (DGPS) equipment. Data collection occurred while navigating along pre-planned range lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. The depth sounder was calibrated daily using a velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod for depth reading verification. During the 2007 survey, team members collected 70,445 data points over cross-sections totaling nearly 72 miles in length. Figure 2 shows where data points were collected during the TWDB 2007 survey.

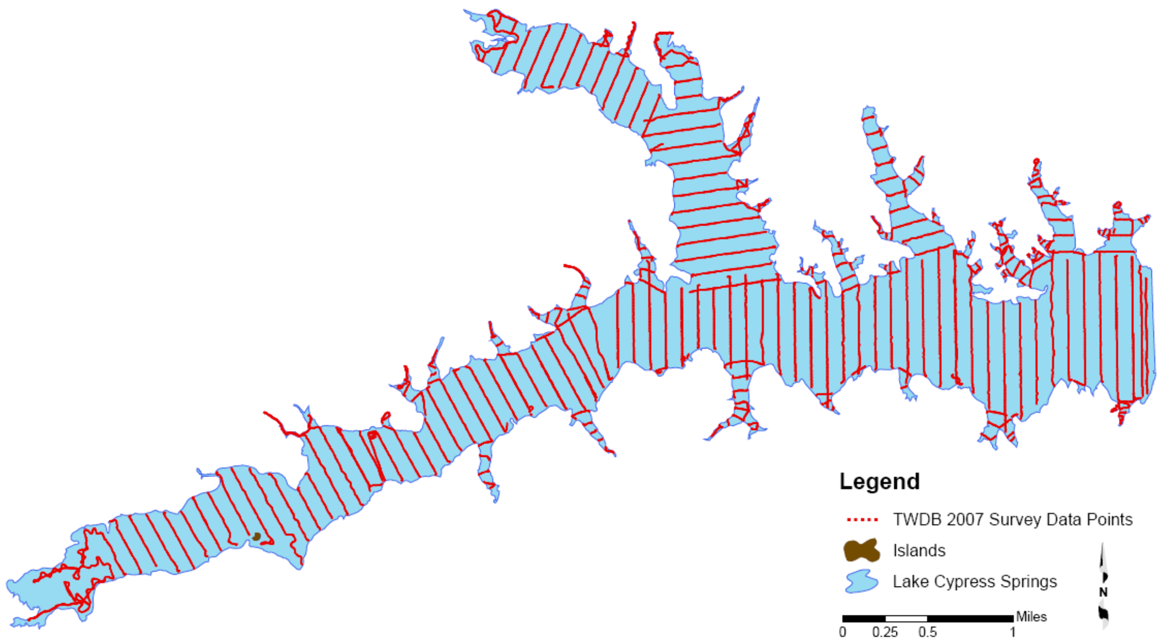


***Figure 2**. Data points collected during TWDB 2007 Survey*

Data Processing

Model Boundaries

The reservoir boundary was digitized from aerial photographs, or digital orthophoto quarter-quadrangle images (DOQQs)[6,7], using Environmental Systems Research Institute's (ESRI) ArcGIS 9.1 software. The quarter-quadrangles that cover Lake Cypress Springs are Purley SE, New Hope NW, New Hope NE, New Hope SW, and New Hope SE. These images were photographed on September 30, 2004, during which time the water surface elevation at Lake Cypress Springs measured 376.98 feet above mean sea level (NGVD29). Although the water surface elevation measured approximately one foot below conservation pool elevation at the time of the photos, TWDB determined that there was not a significant difference in lake area between 376.98 feet and 378.00 feet, as discernable from the photographs and given the photographs have a 1-meter resolution. Therefore, the Lake Cypress Springs boundary was digitized from the land water interface in the aerial photos and labeled 378.00 feet to allow area and volume to be calculated to the conservation pool elevation.

Triangulated Irregular Network (TIN) Model

Upon completion of data collection, the raw data files collected by TWDB were edited using DepthPic and HydroEdit to remove any data anomalies. DepthPic is used to display, interpret, and manually-edit the multi-frequency data, while HydroEdit is used to automatically edit the multi-frequency data and to convert the depth measurements to bathymetric elevations using the known water surface elevation at the time of each sounding. For processing outside of DepthPic and HydroEdit, the sounding coordinates (X,Y,Z) are exported as a MASS points file. TWDB also created a MASS points file of interpolated data located in-between surveyed cross sections. This points file is described in the section entitled "Self-Similar Interpolation."

To create a surface representation of the Lake Cypress Springs bathymetry, the 3D Analyst Extension[8] of ArcGIS (ESRI, Inc.) is used. With this extension, a triangulated irregular network (TIN) model of the bathymetry is created following the Delaunay[8] criteria, where each MASS point and boundary node becomes the vertex of a triangular portion of the reservoir bottom surface. From the TIN model, reservoir capacities and areas are calculated at one-tenth of a foot (0.1 foot) intervals, from elevation 325.0 feet to elevation 378.0 feet.

The Elevation-Capacity and Elevation-Area Tables, updated for 2007, are presented in Appendices A and B, respectively. An Elevation-Area-Capacity graph is presented in Appendix C.

The TIN model was interpolated and averaged using a cell size of 1 foot by 1 foot and converted to a raster. The raster was used to produce Figure 3, an Elevation Relief Map representing the topography of the reservoir bottom, Figure 4, a map showing shaded depth ranges for Lake Cypress Springs, and Figure 5, a 5-foot contour map (attached).

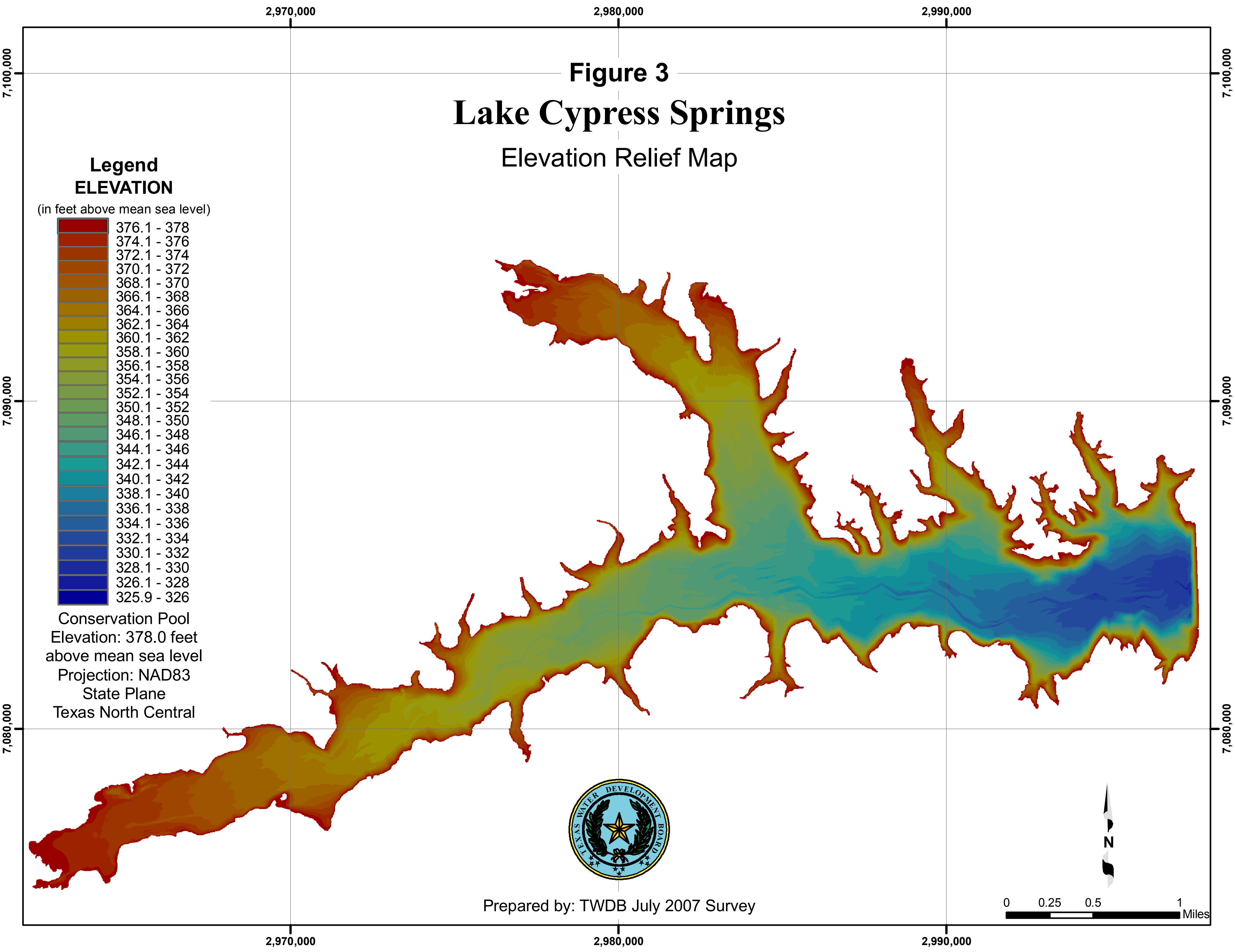


Figure 3
Lake Cypress Springs
Elevation Relief Map
Legend
ELEVATION
(in feet above mean sea level)
376.1 - 378
374.1 - 376
372.1 - 374
370.1 - 372
368.1 - 370
366.1 - 368
364.1 - 366
362.1 - 364
360.1 - 362
358.1 - 360
356.1 - 358
354.1 - 356
352.1 - 354
350.1 - 352
348.1 - 350
346.1 - 348
344.1 - 346
342.1 - 344
340.1 - 342
338.1 - 340
336.1 - 338
334.1 - 336
332.1 - 334
330.1 - 332
328.1 - 330
326.1 - 328
325.9 - 326
Conservation Pool
Elevation: 378.0 feet
above mean sea level
Projection: NAD83
State Plane
Texas North Central
2,970,000
2,980,000
2,990,000
7,100,000
7,090,000
7,080,000
TEXAS WATER DEVELOPMENT BOARD
N
0
0.25
0.5
1
Miles
Prepared by: TWDB July 2007 Survey

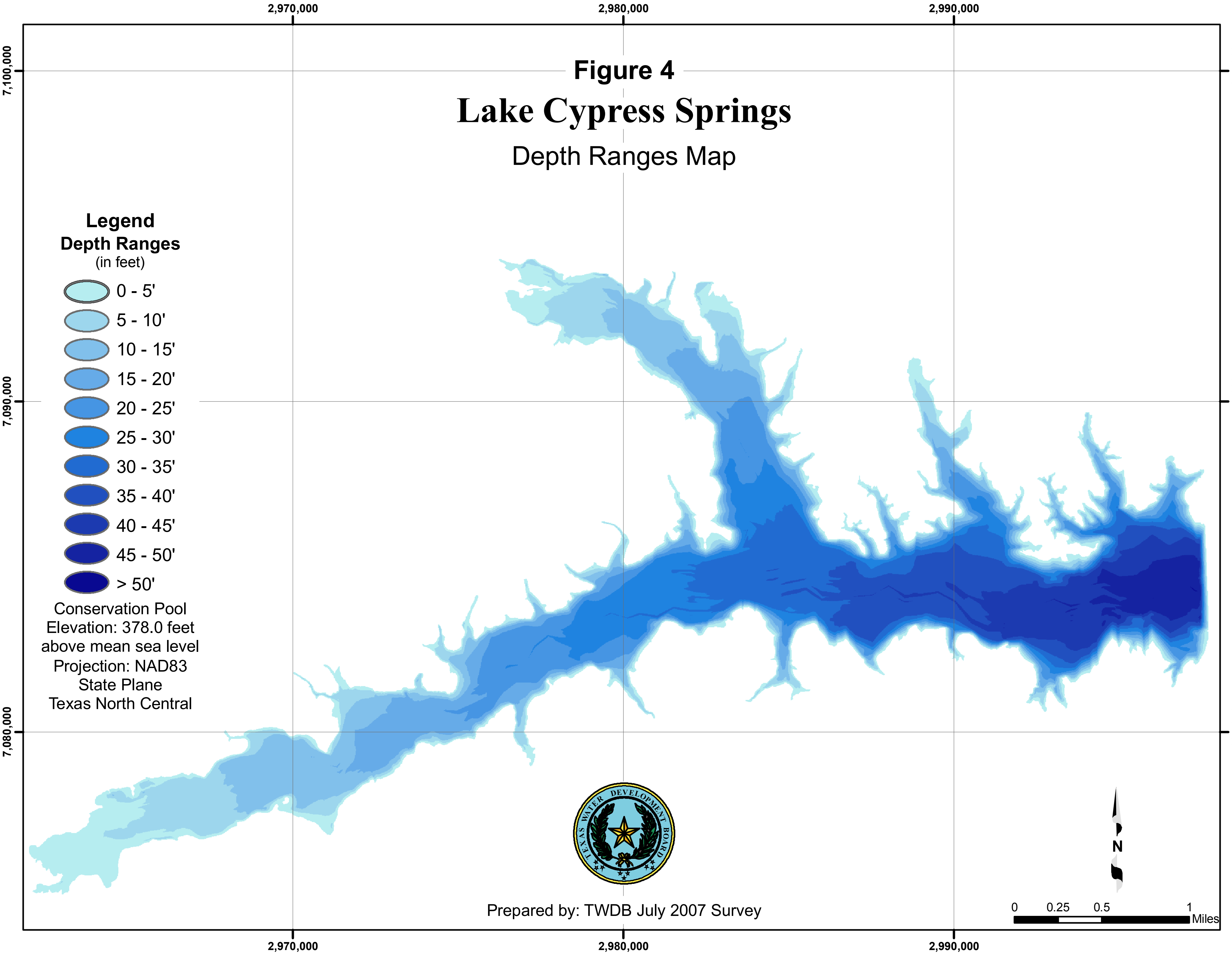


Figure 4
Lake Cypress Springs
Depth Ranges Map
Legend
Depth Ranges
(in feet)
0 - 5'
5 - 10'
10 - 15'
15 - 20'
20 - 25'
25 - 30'
30 - 35'
35 - 40'
40 - 45'
45 - 50'
> 50'
Conservation Pool
Elevation: 378.0 feet
above mean sea level
Projection: NAD83
State Plane
Texas North Central
2,970,000
2,980,000
2,990,000
7,100,000
7,090,000
7,080,000
TEXAS WATER DEVELOPMENT BOARD
N
0
0.25
0.5
1
Miles
Prepared by: TWDB July 2007 Survey

Self-Similar Interpolation

A limitation of the Delaunay method for triangulation when creating TIN models results in artificially-curved contour lines extending into the reservoir where the reservoir walls are steep and the reservoir is relatively narrow. These curved contours are likely a poor representation of the true reservoir bathymetry in these areas. Also, if the surveyed cross sections are not perpendicular to the centerline of submerged river channel (the location of which is often unknown until after the survey), then the TIN model is not likely to well-represent the true channel bathymetry.

To ameliorate these problems, a self-similar interpolation routine (developed by TWDB) was used to interpolate the bathymetry in between many 500 foot-spaced survey lines. The self-similar interpolation technique effectively increases the density of points input into the TIN model, and directs the TIN interpolation to better represent the reservoir topography.[9] In the case of Lake Cypress Springs, the application of self-similar interpolation helped represent the lake morphology near the banks and improved the representation of the submerged river channel (Figure 6). In areas where obvious geomorphic features indicate a high-probability of cross-section shape changes (e.g. incoming tributaries, significant widening/narrowing of channel, etc.), the assumptions used in applying the self-similar interpolation technique are not likely to be valid; therefore, self-similar interpolation was not used in areas of Lake Cypress Springs where a high probability of change between cross-sections exists.[9] Figure 6 illustrates typical results of the application of the self-similar interpolation technique in Lake Cypress Springs, and the bathymetry shown in Figure 6C was used in computing reservoir capacity and area tables (Appendix A, B).

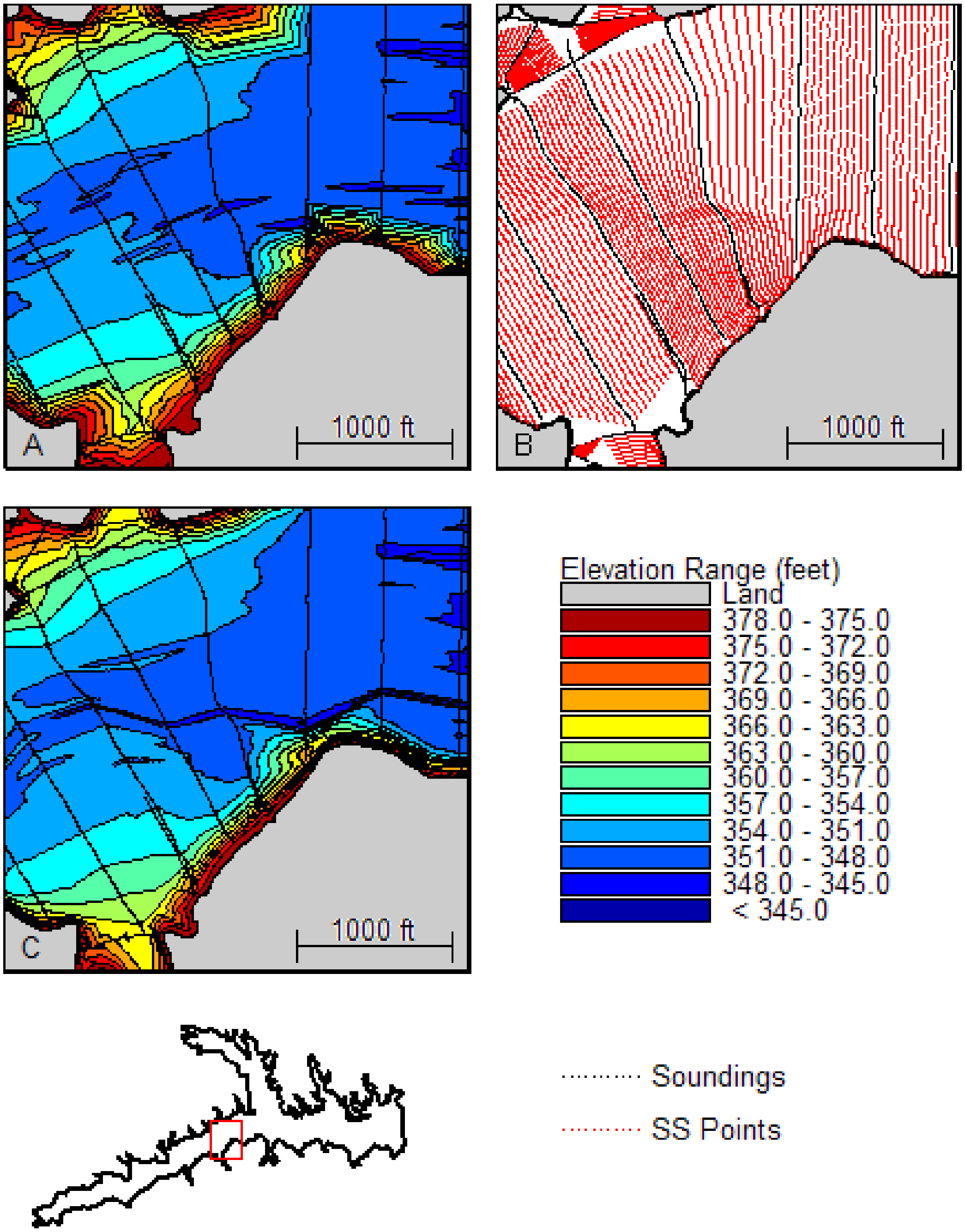


Figure 6 *Application of the Self-Similar Interpolation technique to Lake Cypress Springs 2007 sounding data – A) bathymetric contours without interpolated points, B) Sounding points (black) and interpolated points (red) with reservoir boundary shown at elevation 378.0 feet (black), C) bathymetric contours with the interpolated points. Note: In 6A the steep banks indicated by the surveyed cross sections are not represented for the areas in-between the cross sections. This is an artifact of the TIN generation routine when data points are too far apart. Inclusion of the interpolated points (6C) corrects this and smoothes the bathymetric contours. The submerged river channel is also apparent in 6C where it is discontinuous in 6A.*

Volumetric Survey Results - 2007

The results of the TWDB 2007 Volumetric Survey indicate Lake Cypress Springs has a total reservoir capacity of 66,756 acre-feet and encompasses 3,252 acres at conservation pool elevation (378.0 feet above mean sea level, NGVD29). In 1998 TWDB estimated the capacity of Lake Cypress Springs (at conservation pool elevation) at 67,690 acre-feet.[1] Due to differences in the methodologies used in calculating areas and capacities from this and previous Lake Cypress Springs surveys, comparison of these values is not recommended.[2] The TWDB considers the 2007 survey to be a significant improvement over previous methods and recommends that a similar methodology be used to resurvey Lake Cypress Springs in 10 to 20 years or after a major flood event.

Sediment Survey Results - 2007

The 200 kHz, 50 kHz, and 24 kHz frequency data were used to interpret sediment distribution and accumulation throughout Lake Cypress Springs. Figure 7 shows the thickness of sediment throughout the lake. To assist in the interpretation of post-impoundment sediment accumulation, ancillary data was collected in the form of five core samples. Sediment cores were collected on May 20, 2008 using a Specialty Devices, Inc. VibeCore system.

The results of the TWDB 2007 Sediment Survey indicate Lake Cypress Springs has accumulated 3,807 acre-feet of sediment since impoundment in 1970. Based on this measured sediment volume and assuming a constant sediment accumulation rate, Lake Cypress Springs loses approximately 100 acre-feet of capacity per year. The majority of the sediment accumulation has occurred within the main body of the lake, with the thickest deposits in the submerged Big Cypress Creek channel. The maximum sediment thickness observed in Lake Cypress Springs was 7.2 feet.

A complete description of the sediment measurement methodology and sample results is presented in Appendix D.

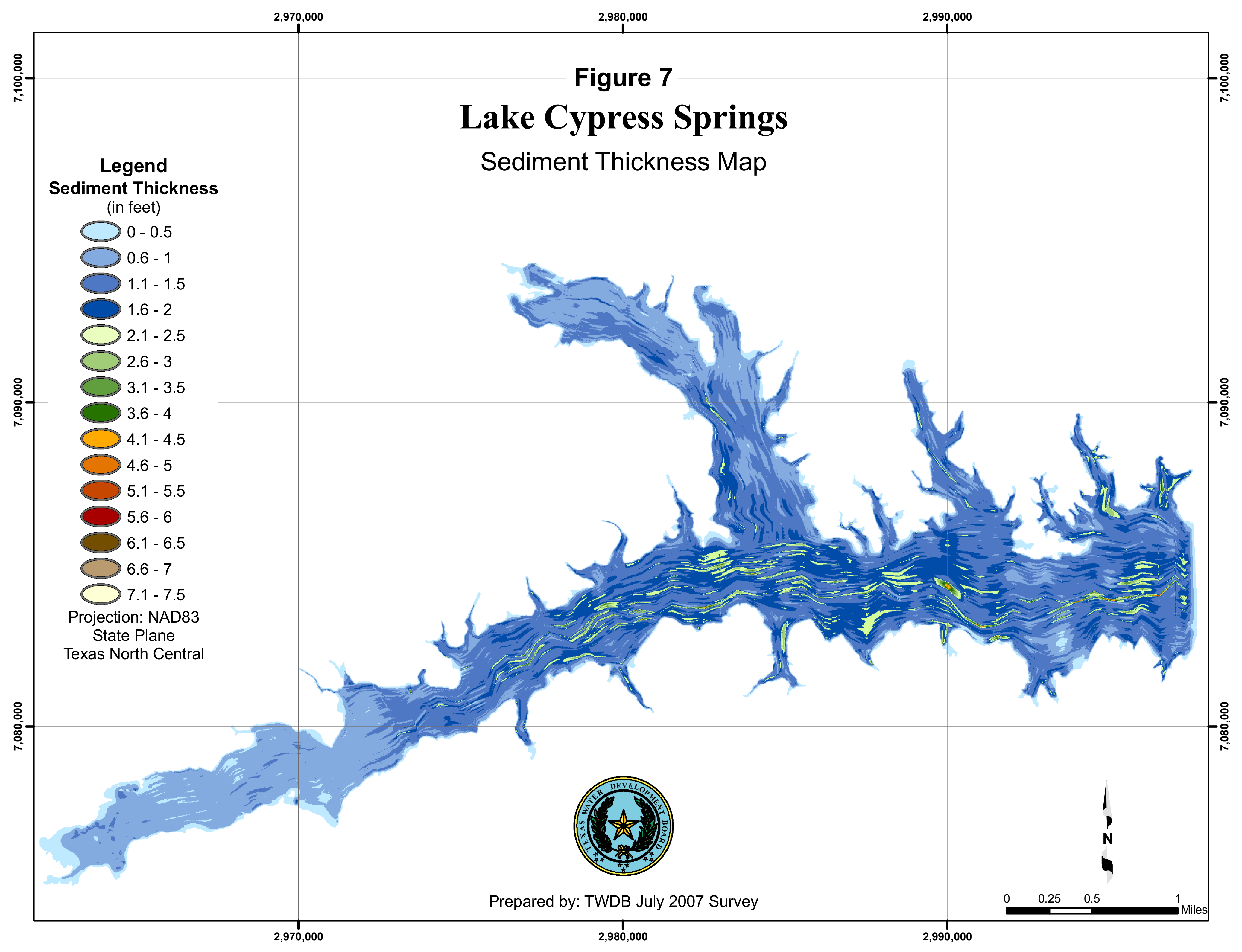


Figure 7
Lake Cypress Springs
Sediment Thickness Map
Legend
Sediment Thickness
(in feet)
0 - 0.5
0.6 - 1
1.1 - 1.5
1.6 - 2
2.1 - 2.5
2.6 - 3
3.1 - 3.5
3.6 - 4
4.1 - 4.5
4.6 - 5
5.1 - 5.5
5.6 - 6
6.1 - 6.5
6.6 - 7
7.1 - 7.5
Projection: NAD83
State Plane
Texas North Central
2,970,000
2,980,000
2,990,000
7,100,000
7,090,000
7,080,000
TEXAS WATER DEVELOPMENT BOARD
N
0
0.25
0.5
1
Miles
Prepared by: TWDB July 2007 Survey

TWDB Contact Information

More information about the Hydrographic Survey Program can be found at:

http://www.twdb.state.tx.us/assistance/lakesurveys/volumetricindex.asp

Any questions regarding the TWDB Hydrographic Survey Program may be addressed to:

Barney Austin, Ph.D., P.E.
Director of the Surface Water Resources Division
Phone: (512) 463-8856
Email: Barney.Austin@twdb.state.tx.us

Or

Jason Kemp
Team Leader, TWDB Hydrographic Survey Program
Phone: (512) 463-2465
Email: Jason.Kemp@twdb.state.tx.us

References

1. Texas Water Development Board (1998) “Volumetric Survey of Lake Cypress Springs”

2. United States Department of Agriculture, Natural Resource Conservation Service, National Engineering Handbook, Section 3, Sedimentation, Chapter 7, Field Investigations and Surveys, December 1983.

3. Texas Water Development Board, Report 126, Engineering Data on Dams and Reservoirs in Texas, Part I, October 1974.

4. Franklin County Water District, viewed March 18, 2008, http://www.fcwd.com/.

5. United States Geological Survey, http://tx.usgs.gov/ 07 June 2006.

6. Texas Natural Resources Information System (TNRIS), viewed 31 October 2007, http://www.tnris.state.tx.us/.

7. U.S Department of Agriculture, Farm Service Agency, Aerial Photography Field Office, National Agriculture Imagery Program, viewed February 10, 2006 http://www.apfo.usda.gov/NAIP.html.

8. ESRI, Environmental Systems Research Institute. 1995. ARC/INFO Surface Modeling and Display, TIN Users Guide.

9. Furnans, Jordan. Texas Water Development Board. 2006. “HydroEdit User’s Manual.”

Appendix A

Lake Cypress Springs

RESERVOIR CAPACITY TABLE

TEXAS WATER DEVELOPMENT BOARD — JULY 2007 SURVEY

CAPACITY IN ACRE-FEET — Conservation Pool Elevation 378.0 Feet NGVD29

ELEVATION INCREMENT IS ONE TENTH FOOT

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
325	0	0	0	0	0	0	0	0	0	0
326	0	0	0	0	0	0	0	0	0	0
327	0	0	0	0	0	0	0	0	0	0
328	0	0	0	0	0	0	0	0	0	0
329	0	1	1	1	1	1	1	1	1	1
330	2	2	2	2	3	3	4	5	6	7
331	9	10	12	14	16	19	22	25	29	33
332	37	42	47	53	59	66	74	82	90	99
333	109	119	130	141	153	165	178	191	205	219
334	233	249	264	280	296	313	330	348	366	384
335	403	422	441	461	481	502	523	545	567	589
336	613	636	660	684	708	733	759	784	810	836
337	863	890	917	945	974	1,003	1,032	1,062	1,092	1,122
338	1,153	1,184	1,216	1,248	1,280	1,313	1,346	1,380	1,414	1,449
339	1,484	1,520	1,556	1,592	1,629	1,667	1,705	1,744	1,783	1,823
340	1,863	1,904	1,946	1,989	2,032	2,077	2,122	2,168	2,215	2,262
341	2,310	2,359	2,408	2,458	2,508	2,559	2,611	2,662	2,715	2,768
342	2,821	2,875	2,930	2,985	3,040	3,097	3,153	3,211	3,269	3,327
343	3,386	3,445	3,505	3,566	3,627	3,689	3,751	3,814	3,877	3,942
344	4,006	4,072	4,138	4,204	4,271	4,338	4,406	4,475	4,544	4,613
345	4,683	4,753	4,824	4,896	4,968	5,041	5,115	5,190	5,265	5,341
346	5,418	5,496	5,574	5,653	5,733	5,813	5,895	5,977	6,059	6,142
347	6,226	6,311	6,396	6,482	6,569	6,656	6,744	6,833	6,922	7,012
348	7,103	7,194	7,287	7,380	7,474	7,569	7,664	7,760	7,857	7,954
349	8,052	8,150	8,249	8,349	8,449	8,550	8,651	8,753	8,855	8,958
350	9,062	9,166	9,270	9,375	9,481	9,587	9,694	9,801	9,910	10,019
351	10,128	10,239	10,349	10,461	10,573	10,686	10,799	10,913	11,028	11,143
352	11,259	11,376	11,493	11,611	11,729	11,848	11,968	12,088	12,209	12,331
353	12,453	12,576	12,700	12,824	12,949	13,075	13,201	13,328	13,456	13,584
354	13,712	13,842	13,972	14,102	14,233	14,365	14,497	14,630	14,764	14,898
355	15,033	15,168	15,305	15,442	15,580	15,719	15,858	15,998	16,139	16,280
356	16,422	16,565	16,708	16,852	16,997	17,143	17,289	17,436	17,583	17,732
357	17,881	18,031	18,181	18,332	18,484	18,636	18,789	18,943	19,097	19,251
358	19,407	19,563	19,720	19,877	20,035	20,194	20,353	20,513	20,673	20,835
359	20,997	21,159	21,322	21,486	21,650	21,816	21,981	22,148	22,315	22,482
360	22,651	22,820	22,990	23,160	23,331	23,503	23,676	23,850	24,024	24,199
361	24,374	24,551	24,728	24,906	25,084	25,264	25,444	25,625	25,807	25,990
362	26,174	26,358	26,543	26,729	26,915	27,102	27,290	27,478	27,667	27,857
363	28,047	28,238	28,430	28,623	28,816	29,010	29,205	29,400	29,597	29,794
364	29,992	30,191	30,391	30,591	30,793	30,995	31,198	31,402	31,606	31,812
365	32,018	32,225	32,433	32,642	32,852	33,063	33,275	33,488	33,702	33,917
366	34,133	34,350	34,568	34,786	35,006	35,226	35,447	35,669	35,892	36,116
367	36,342	36,568	36,795	37,023	37,253	37,483	37,714	37,947	38,180	38,414
368	38,649	38,885	39,123	39,360	39,599	39,839	40,080	40,321	40,563	40,807
369	41,051	41,296	41,542	41,788	42,036	42,284	42,534	42,784	43,035	43,287
370	43,540	43,794	44,048	44,304	44,560	44,817	45,076	45,335	45,594	45,855
371	46,116	46,379	46,642	46,906	47,171	47,437	47,704	47,972	48,240	48,510
372	48,781	49,053	49,325	49,599	49,874	50,150	50,426	50,704	50,983	51,262
373	51,543	51,825	52,107	52,391	52,675	52,961	53,248	53,536	53,824	54,114
374	54,405	54,698	54,991	55,285	55,580	55,876	56,173	56,472	56,772	57,072
375	57,374	57,676	57,980	58,284	58,589	58,895	59,201	59,508	59,816	60,124
376	60,433	60,743	61,053	61,364	61,676	61,988	62,301	62,615	62,929	63,244
377	63,560	63,876	64,193	64,511	64,829	65,148	65,468	65,789	66,110	66,433
378	66,756									

Appendix B

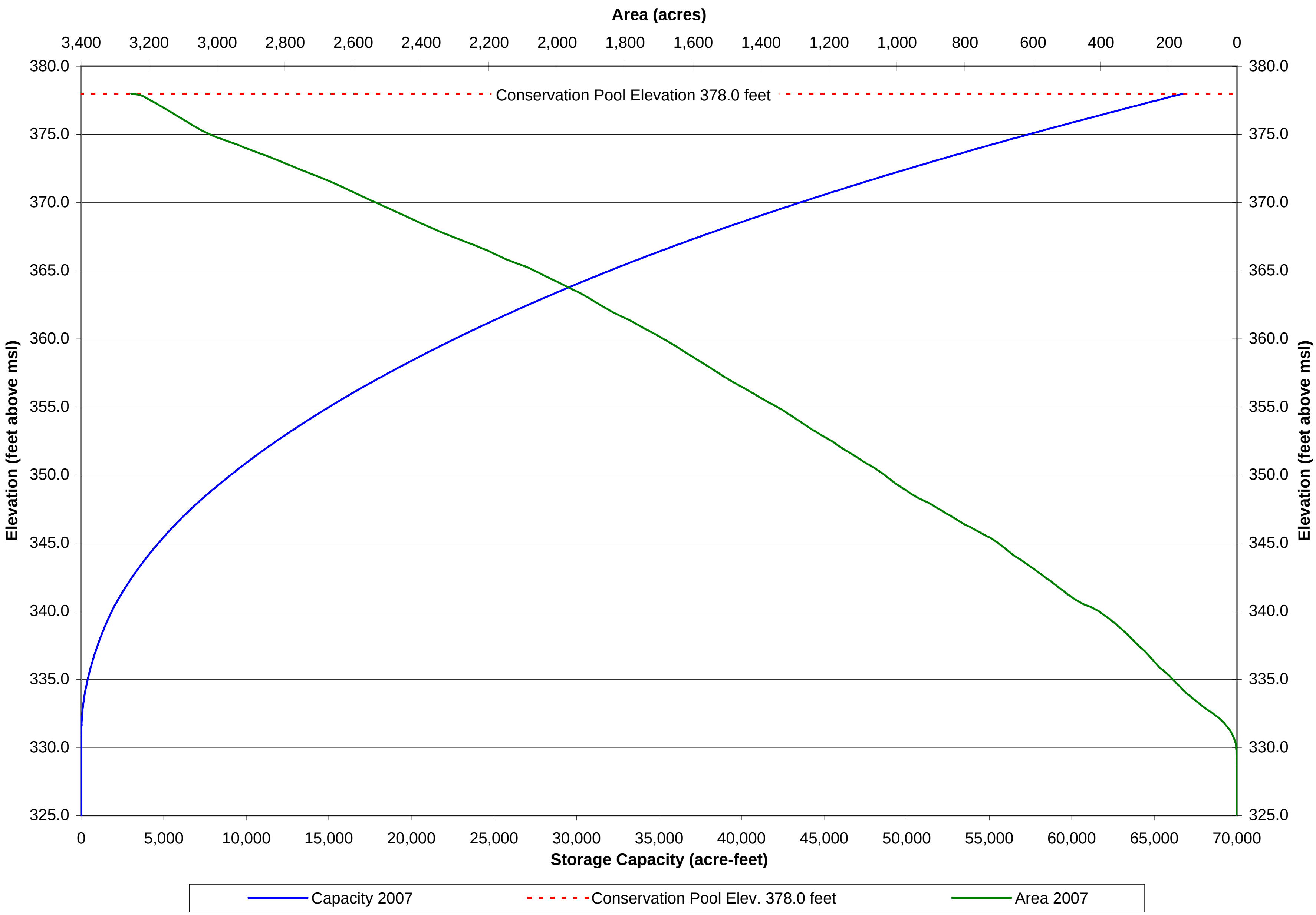
Lake Cypress Springs

RESERVOIR AREA TABLE

TEXAS WATER DEVELOPMENT BOARD
AREA IN ACRES
ELEVATION INCREMENT IS ONE TENTH FOOT

JULY 2007 SURVEY
Conservation Pool Elevation 378.0 Feet NGVD29

ELEVATION in Feet	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
325	0	0	0	0	0	0	0	0	0	0
326	0	0	0	0	0	0	0	0	0	0
327	0	0	0	0	0	0	0	0	0	0
328	0	0	0	0	0	0	0	0	0	1
329	1	1	1	1	1	1	1	1	2	2
330	2	2	3	4	5	6	8	9	11	13
331	15	17	19	21	25	28	31	35	38	42
332	46	51	55	60	66	71	77	83	88	94
333	100	105	109	114	119	125	130	135	139	144
334	149	153	157	161	165	169	173	177	181	185
335	189	193	196	200	205	209	214	219	224	229
336	233	236	240	243	247	250	254	257	261	265
337	268	273	277	282	286	290	294	298	302	306
338	310	314	318	322	327	331	335	340	345	349
339	353	358	364	369	373	378	385	390	395	401
340	407	413	421	429	441	449	457	465	472	478
341	484	489	495	501	506	511	516	522	527	532
342	537	542	548	553	560	565	570	575	581	586
343	592	597	603	609	615	620	626	631	638	645
344	650	656	662	667	672	677	682	687	692	697
345	702	707	713	720	726	734	742	750	757	764
346	772	779	786	795	803	809	816	822	829	836
347	842	849	856	863	870	876	883	890	897	903
348	911	920	929	937	944	950	957	963	969	975
349	981	988	994	1,000	1,005	1,011	1,016	1,021	1,026	1,031
350	1,037	1,042	1,048	1,053	1,059	1,065	1,072	1,079	1,086	1,093
351	1,099	1,105	1,111	1,118	1,124	1,131	1,137	1,144	1,151	1,157
352	1,163	1,170	1,175	1,181	1,186	1,193	1,200	1,207	1,213	1,220
353	1,227	1,234	1,240	1,247	1,253	1,260	1,266	1,272	1,278	1,284
354	1,290	1,296	1,302	1,308	1,314	1,320	1,326	1,332	1,339	1,346
355	1,353	1,360	1,368	1,375	1,383	1,390	1,397	1,404	1,410	1,417
356	1,424	1,431	1,438	1,445	1,452	1,459	1,466	1,473	1,480	1,487
357	1,495	1,501	1,507	1,514	1,520	1,526	1,532	1,538	1,544	1,551
358	1,557	1,564	1,570	1,577	1,583	1,590	1,596	1,602	1,609	1,616
359	1,622	1,629	1,635	1,641	1,647	1,654	1,660	1,667	1,674	1,680
360	1,688	1,695	1,702	1,709	1,716	1,723	1,731	1,739	1,746	1,753
361	1,760	1,767	1,775	1,782	1,790	1,798	1,807	1,816	1,824	1,832
362	1,839	1,847	1,854	1,861	1,867	1,874	1,881	1,887	1,894	1,900
363	1,907	1,914	1,921	1,928	1,936	1,944	1,953	1,961	1,969	1,977
364	1,985	1,993	2,002	2,010	2,018	2,026	2,034	2,042	2,050	2,058
365	2,066	2,075	2,083	2,093	2,103	2,115	2,126	2,136	2,146	2,155
366	2,164	2,173	2,182	2,190	2,198	2,207	2,216	2,227	2,237	2,247
367	2,256	2,267	2,278	2,288	2,298	2,308	2,318	2,329	2,338	2,347
368	2,356	2,366	2,375	2,384	2,393	2,402	2,411	2,419	2,428	2,436
369	2,445	2,454	2,463	2,471	2,480	2,489	2,498	2,507	2,515	2,524
370	2,533	2,542	2,551	2,560	2,568	2,577	2,585	2,594	2,602	2,611
371	2,619	2,628	2,637	2,645	2,654	2,664	2,673	2,682	2,692	2,702
372	2,713	2,723	2,733	2,743	2,753	2,762	2,772	2,782	2,792	2,801
373	2,811	2,821	2,831	2,840	2,851	2,862	2,873	2,883	2,894	2,906
374	2,916	2,926	2,935	2,945	2,957	2,969	2,980	2,992	3,002	3,011
375	3,021	3,030	3,038	3,046	3,053	3,060	3,067	3,074	3,080	3,087
376	3,093	3,100	3,107	3,113	3,120	3,126	3,133	3,140	3,147	3,153
377	3,160	3,167	3,174	3,181	3,188	3,195	3,203	3,210	3,218	3,226
378	3,252									



Lake Cypress Springs
July 2007 Survey
Prepared by: TWDB

Appendix C: Area and Capacity Curves

Appendix D

Analysis of Sediment Accumulation Data from Lake Cypress Springs

Executive Summary

The results of the TWDB 2007 Sedimentation Survey indicate Lake Cypress Springs has accumulated 3,807 acre-feet of sediment since impoundment in 1970. Based on this measured sediment volume and assuming a constant rate of sediment accumulation, Lake Cypress Springs loses approximately 100 acre-feet of capacity per year. The majority of the sediment accumulation has occurred within the main body of the lake, with the thickest deposits in the submerged Big Cypress Creek channel. The maximum sediment thickness observed in Lake Cypress Springs was 7.2 feet.

Introduction

This appendix includes the results of the sediment investigation using multi-frequency depth sounder data collected on June 21st, June 27th-June 29th, July 10th, and July 11th of 2007 by the Texas Water Development Board (TWDB). Through careful analysis and interpretation of the multi-frequency signal returns, it is possible to discern the pre-impoundment bathymetric surface, as well as the current surface and sediment thickness. Such interpretations are aided and validated through comparisons with sediment core samples which provide independent measurements of sediment thickness. On May 20, 2008 TWDB collected five core samples of the impoundment bottom throughout the reservoir. The remainder of this appendix presents a discussion of the results from and methodology used in the core sampling and multi-frequency data collection efforts, followed by a composite analysis of sediment measured in Lake Cypress Springs.

Data Collection & Processing Methodology

TWDB conducted the Lake Cypress Springs bathymetric survey on June 21st, June 27th-June 29th, July 10th, and July 11th of 2007, while the water surface elevation ranged between 378.22 feet and 379.42 feet above mean sea level (NGVD29). For all data collection efforts, TWDB used a Specialty Devices, Inc., multi-frequency (200 kHz, 50 kHz, and 24 kHz) sub-bottom profiling depth sounder integrated with Differential Global Positioning System (DGPS) equipment. Data collection occurred while navigating along pre-planned range lines oriented perpendicular to the assumed location of the original river channels and spaced approximately 500 feet apart. For all data collection efforts, the depth sounder was calibrated daily using a velocity profiler to measure the speed of sound in the water column and a weighted tape or stadia rod for depth reading verification. During the 2007 survey, team members collected 70,445 data points over cross-sections totaling nearly 72 miles in length. Figure E1 shows where data points were collected during the TWDB 2007 survey. The coordinates and a description of each core sample are provided in Table E1.

Core samples collected by TWDB were collected at locations where sounding data had been previously collected (Figure E1). All cores were collected with a custom-coring boat and SDI VibraCore system. Cores were analyzed by TWDB, and both the sediment thickness and the distance the core penetrated the pre-impoundment boundary were recorded. Figure E2 shows the cross-section of sediment core #1. At this location, TWDB collected 18” of sediment, with the upper sediment layers (Figure E2) having a high water content, consisting of clay material and lacking in vegetation. The pre-impoundment boundary was evident from this core at a distance of 10” above the core base; above this location, the moisture content in the sediment greatly increases (Figure E2).

Table D1 – Core Sampling Analysis Data

Core	Easting** (ft)	Northing** (ft)	Description
1	2984546.46	7083312.15	18" of muddy sediment with plant material visible.
2	2972427.51	7079991.96	18" of alternating muddy and sandy sediment, dry clay found 32" below pre-impoundment boundary
3	2968465.25	7077895.17	15" of clay sediment, dark color with orange spots.
4	2983536.81	7089095.45	12" of wet, fine grained sediment (clay)
5	2995017.84	7086446.74	16" of sediment with little plant material visible.

** Coordinates are based on NAD 1983 State Plane Texas North Central system

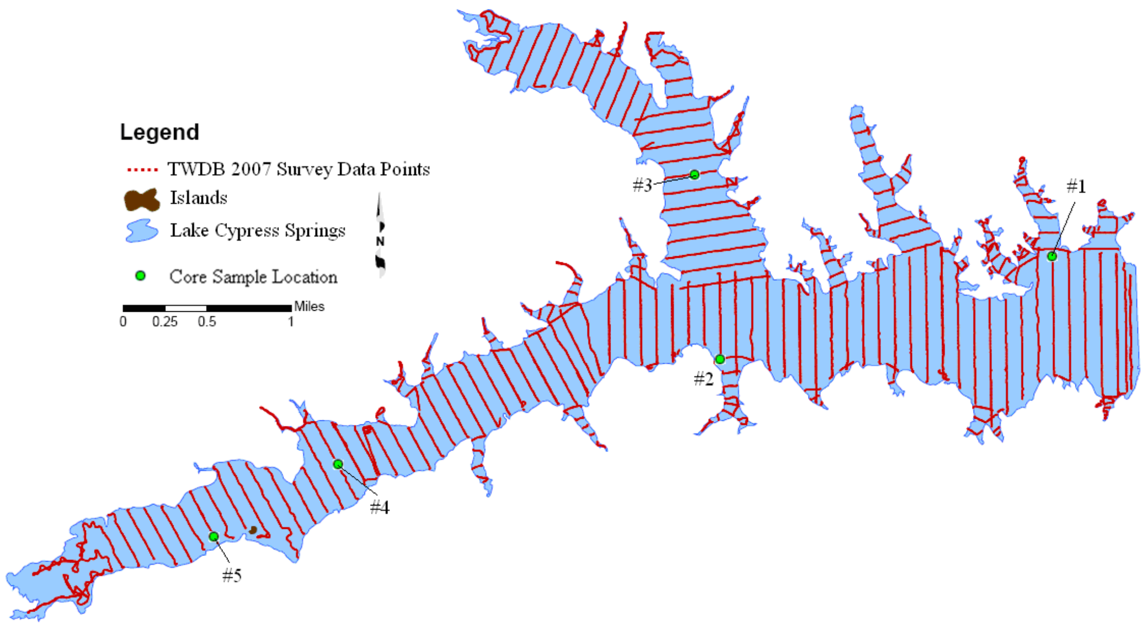


Figure E1 – TWDB 2007 survey data points for Lake Cypress Springs

Figure E2 – Upper portion of core #1 from Lake Cypress Springs, showing the pre-impoundment boundary 10" above the base of the core (left).

All sounding data is processed using the DepthPic software, within which both the pre-impoundment and current bathymetric surfaces are identified and digitized manually. These surfaces are first identified along cross-sections for which core samples have been collected – thereby allowing the user to identify color bands in the DepthPic display that correspond to the sediment layer(s) observed in the core samples. This process is illustrated in Figure E3 where core sample #1 is shown with its corresponding sounding data. Core sample #1 contained 18" of sediment above the pre-impoundment bathymetry, as indicated by the yellow & green boxes, respectively, representing the core sample in Figure E3. The pre-impoundment surface is usually identified within the core sample by one of the following methods: (1) a visual examination of the core for in-place terrestrial materials, such as leaf litter, tree bark, twigs, intact roots, etc., concentrations of which tend to occur on or just below the pre-impoundment surface, (2) changes in texture from well sorted, relatively fine-grained sediment to poorly sorted mixtures of coarse and fine-grained materials, and (3) variations in the physical properties of the sediment, particularly sediment water content and penetration resistance with depth.

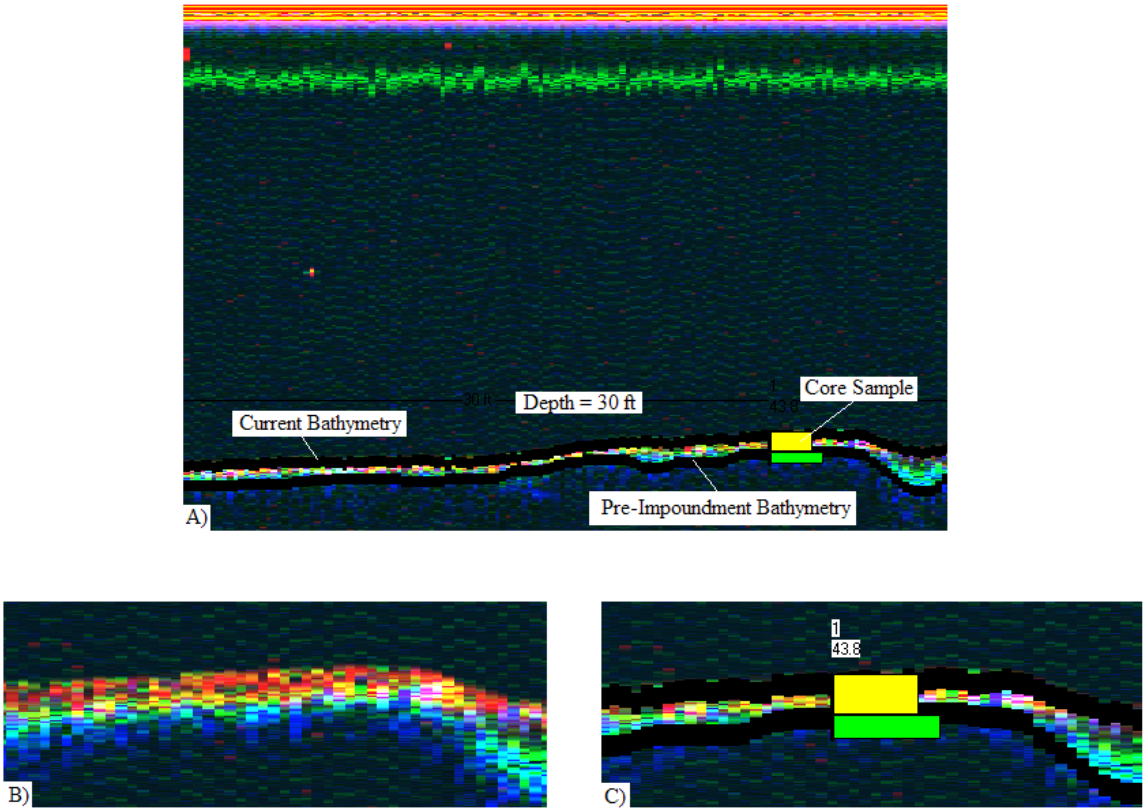


Figure E3 – DepthPic & core sample use in identifying the pre-impoundment bathymetry.

Within DepthPic, the current surface is automatically determined based on the signal returns from the 200 kHz transducer. The pre-impoundment surface must be determined visually based on the pixel color display and any available core sample data. Based on core sample #1, it is clear that the pre-impoundment bathymetric surface for this cross-section may be identified as the base of the bright-colored blue pixels in the DepthPic display. The top of the sediment layer is also clearly identifiable as the band of red and green pixels (Figure E3).

In analyzing data from cross-sections where core samples were not collected, the assumption is made that sediment layers may be identified in a similar manner as when core sample data is available. To improve the validity of this assumption, core samples are collected at regularly spaced intervals within the lake, or at locations where interpretation of the DepthPic display would be difficult without site-specific core data. For this reason, all sounding data is collected and reviewed before core sites are selected and cores are collected.

After manually digitizing the pre-impoundment surface from all cross-sections, both the pre-impoundment and current bathymetric surfaces are exported as X-,Y-,Z-coordinates from DepthPic into text files suitable for use in ArcGIS. Within ArcGIS, the sounding points are then processed into TIN models following standard GIS techniques[1].

Results

The results of the TWDB 2007 Sediment Survey indicate Lake Cypress Springs has accumulated 3,807 acre-feet of sediment since impoundment in 1970. Based on this measured sediment volume and assuming a constant sediment accumulation rate, Lake Cypress Springs loses approximately 100 acre-feet of capacity per year. The majority of the sediment accumulation has occurred within the main body of the lake, with the thickest deposits in the submerged Big Cypress Creek channel. The maximum sediment thickness observed in Lake Cypress Springs was 7.2 feet.

The accumulated sediment volume for Lake Cypress Springs was calculated from a sediment thickness TIN model created in ArcGIS. Sediment thicknesses were computed as the difference in elevations between the current and pre-impoundment bathymetric surfaces as determined with the DepthPic software. Sediment thicknesses were interpolated for locations between surveyed cross-sections using the TWDB self-similar interpolation technique[2]. For the purposes of the TIN model creation, TWDB assumed 0-feet sediment thicknesses at the model boundaries (defined as the 378.0 foot NGVD29 elevation contour). Figure E4 depicts the sediment thickness in Lake Cypress Springs.

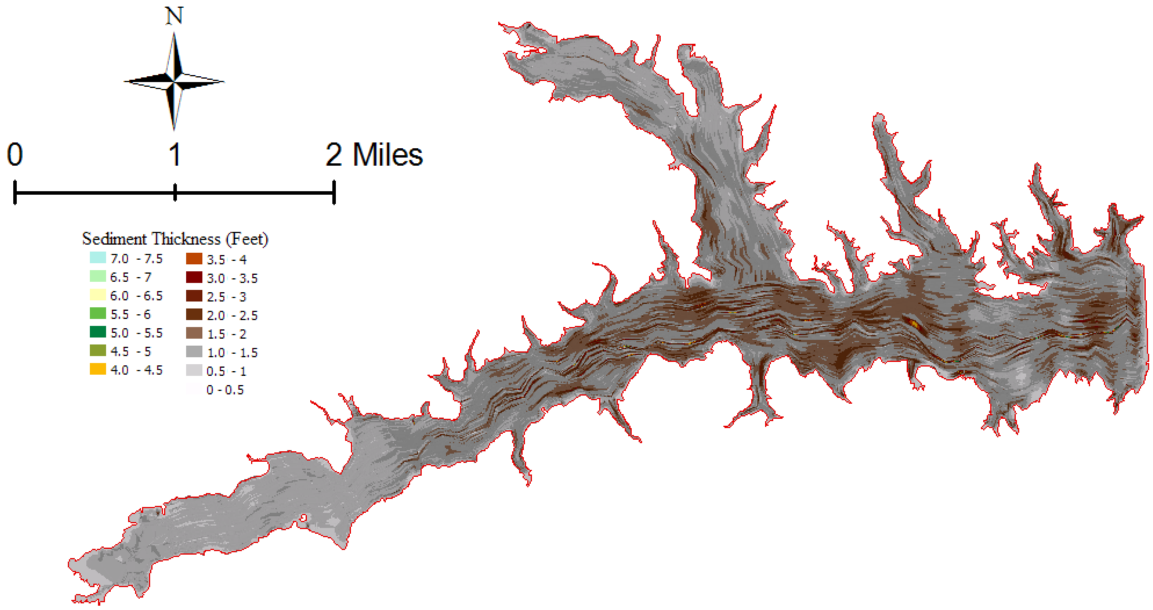


Figure E4 - Sediment thicknesses in Lake Cypress Springs derived from multi-frequency sounding data.

References

1. Furnans, J., Austin, B., Hydrographic survey methods for determining reservoir volume, Environmental Modelling & Software (2007), doi: 10.1016/j.envsoft.2007.05.011
2. Furnans, Jordan. Texas Water Development Board. 2006. "HydroEdit User's Manual."

Figure 5

CONTOURS
(in feet above mean sea level)

- 375
- 370
- 365
- 360
- 355
- 350
- 345
- 340
- 335
- 330

- Islands
- Lake Cypress Springs

Conservation Pool Elevation:
378 feet above mean seal level

Projection: NAD83
State Plane
Texas North Central

This map is the product of a survey conducted by the Texas Water Development Board's Hydrographic Survey Program to determine the capacity of Lake Cypress Springs. The Texas Water Development Board makes no representation or assumes any liability.

Lake Cypress Springs - 5' Contour Map

N

0 0.25 0.5 1 Miles

Franklin County

Prepared by: TEXAS WATER DEVELOPMENT BOARD July 2007 Survey

APPENDIX C
DETAILED OPCC

Lake Cypress Springs Emergency Spillway Revitalization

DRAFT Opinion of Probable Construction Cost (OPCC)

Project Number: 10070A.00

Item #	Description	ALTERNATIVE 2 PROPOSED COSTS: Est. Qu. #	Unit	Estimated Unit Price $	Estimated Cost	ALTERNATIVE 3A PROPOSED COSTS: Est. Qu. #	Unit	Estimated Unit Price $	Estimated Cost	ALTERNATIVE 3B PROPOSED COSTS: Est. Qu. #	Unit	Estimated Unit Price $	Estimated Cost
START-UP, MOBILIZATION, SECURITY, & SW3P ITEMS													
A	Mobilization. Shown as a percentage of total construction minus mobilization	3	%	$1,085,000	$32,550	3	%	$726,250	$21,788	3	%	$555,000	$16,650
B	Installation of filter fabric fence, complete in place, maintained during entire project and removed at final completion of project. Includes temporary seeding, hay bales, and SWPP.	8,000	LF	$5	$40,000	8,000	LF	$5	$40,000	8,000	LF	$5	$40,000
C	Installation of stabilized construction entrance and access road, complete in place and maintained during entire project.	2	LS	$6,250	$12,500	2	LS	$6,250	$12,500	2	LS	$6,250	$12,500
				START-UP, MOBILIZATION,	**$85,050**			**START-UP, MOBILIZATION,**	**$74,288**			**START-UP, MOBILIZATION,**	**$69,150**
EMERGENCY SPILLWAY DIRT WORK ITEMS													
A	Excavation of proposed emergency spillway fill material. Includes necessary site preparation and proper **disposal offsite** at identified areas around the lake that can likely receive fill.	105,000	CY	$7.00	$735,000	0	CY	$7.00	$0	0	CY	$7.00	$0
B	Excavation of proposed emergency spillway fill material. Includes necessary site preparation and proper **placement onsite** at identified portion of the emergency spillway that can likely receive fill (pending hydraulic modeling). This line item assumes haul material must **cross the road** to be deposited.	0	CY	$3.85	$0	25,000	CY	$3.85	$96,250	0	CY	$3.85	$0
C	Excavation of proposed emergency spillway fill material. Includes necessary site preparation and proper **placement onsite** at identified portion of the emergency spillway that can likely receive fill (pending hydraulic modeling). This line item assumes haul material must NOT **cross the road** to be deposited.	0	CY	$3.50	$0	80,000	CY	$3.50	$280,000	105,000	CY	$3.50	$367,500
D	Regrading existing access dirt roadway for FCWD tenant property access	2,500	LF	$2	$5,000	2,500	LF	$2	$5,000	2,500	LF	$2	$5,000
E	Hydro mulch revegetation and restoration.	50	AC	$2,600	$130,000	50	AC	$2,600	$130,000	50	AC	$2,600	$130,000
				EMERGENCY SPILLWAY DIRT	**$870,000**			**EMERGENCY SPILLWAY DIRT**	**$511,250**			**EMERGENCY SPILLWAY DIRT**	**$502,500**
FM 3122 ROAD RENOVATION ITEMS													
A	Demolition, removal and proper disposal offsite of existing asphalt roadway, fencing, culvert pipe, and existing appurtenant structures for preparation of new roadway construction. Assumed 25' width x 6" depth.	1,000	LF	$29.50	$29,500	1,000	LF	$29.50	$29,500	0	LF	$29.50	$0
B	Installation of 36" culvert pipes (3) and wingwalls, including, but not limited to excavation, shoring, backfill, bedding, grouting, pipeline connections, post- installation inspection, and all other incidentals, complete in place.	3	BARRELS	$10,000.00	$30,000	3	BARRELS	$10,000.00	$30,000	0	BARRELS	$10,000.00	$0
C	Installation of 18-inch thick limestone rip-rap for all structures, and culverts including, geotextile, placement of material, and any backfill necessary, complete in place.	25	TN	$200.00	$5,000	25	TN	$200.00	$5,000	0	TN	$200.00	$0
D	Replacement of FM3122 roadway (25 ft wide), including all site preparation, base stabilization, placement of asphalt (assumed 2" thick), restriping, and any backfill necessary, and all other incidentals, complete in place.	1,000	LF	$90.00	$90,000	1,000	LF	$90.00	$90,000	0	LF	$90.00	$0
E	Guard Rail Fabrication & Installation as shown on Drawings, including all fastening hardware, complete in place	100	LF	$80.00	$8,000	100	LF	$80.00	$8,000	0	LF	$80.00	$0
				FM 3122 ROAD RENOVATION	**$162,500**			**FM 3122 ROAD RENOVATION**	**$162,500**			**FM 3122 ROAD RENOVATION**	**$0**
DESIGN FEES (SURVEY, GEOTECH, ENGINEERING, ETC.)													
1	**Engineering Design**												
A	ENGINEERING DESIGN. Shown as a percentage of total construction cost.	8	%	$1,117,550	$89,404	8	%	$748,038	$59,843	8	%	$571,650	$45,732
B	CONSTRUCTION MANAGEMENT. Shown as a percentage of total construction cost.	4	%	$1,117,550	$44,702	4	%	$748,038	$29,922	4	%	$571,650	$22,866
C	SURVEY. Shown as a percentage of total construction cost.	2	%	$1,117,550	$22,351	2	%	$748,038	$14,961	2	%	$571,650	$11,433
D	ENGINEERING TESTING. Shown as a percentage of total construction cost.	1	%	$1,117,550	$11,176	1	%	$748,038	$7,480	1	%	$571,650	$5,717
2	**Environmental Permitting**												
A	Wetland Determination and Delineation and Permitting	1	LS	$20,000.00	$20,000	1	LS	$20,000.00	$20,000	1	LS	$20,000.00	$20,000
				DESIGN SUBTOTAL:	**$187,633**			**DESIGN SUBTOTAL:**	**$132,206**			**DESIGN SUBTOTAL:**	**$105,748**

MAJOR ITEMS	ALTERNATIVE 2 PROPOSED COSTS		ALTERNATIVE 3A PROPOSED COSTS		ALTERNATIVE 3B PROPOSED COSTS	
START-UP, MOBILIZATION, SECURITY, & SW3P ITEMS	$85,050		$74,288		$69,150	
EMERGENCY SPILLWAY DIRT WORK ITEMS	$870,000		$511,250		$502,500	
FM 3122 ROAD RENOVATION ITEMS	$162,500		$162,500		$0	
DESIGN FEES (SURVEY, GEOTECH, ENGINEERING, ETC.)	$187,633		$132,206		$105,748	
CONTINGENCY	**20%**	$261,036.50	**20%**	$176,048.63	**20%**	$135,479.50
PROPOSED OPINION OF TOTAL ESTIMATED COST:	**$1,566,000**		**$1,056,000**		**$813,000**	

Cost Qualifiers	
1	On-site haul was assumed to mean fill from areas needing excavation and placed within the existing emergency spillway boundary.
2	Costs were derived from previous bid amounts and engineering judgment. Some of the construction costs were derived from the average low-bid unit prices from TxDOT statewide on a 3-month moving average. Some costs are based on best engineering knowledge of historical pricing.
3	Carollo is not responsible for fluctuation in cost of material, labor components or unforeseen contingencies. The cost estimate has been prepared at the request of the client prior to the finalization of plans and specifications and, therefore is subject to change.
4	This statement of probability of costs are made on the basis of professional experience and qualifications. This represents Carollo's best judgment as a professional design consultant familiar with the construction industry.
5	This is a cost estimate only. These figures are supplied as a guide only. Experience indicates that a fewer number of bidders may result in higher bids, conversely an increased number of bidders may result in more competitive bids.
6	In examining tasks with regard to cost, because this estimate is for the purpose of planning, estimated tasks are based on engineering judgment and historical knowledge. Also, the cost to complete each task should be considered high-level and subject to change as detailed information (survey, environmental, permitting, funding, etc.) is developed. Methods of analysis used in the development of this cost estimate are consistent with a planning level of this detail. The cost required to complete these tasks is intended only as 1) a guide for preliminary and follow-on detailed engineering and 2) a basis for preliminary estimate of time to complete the intended modifications. While procedures consistent with this cost estimate are generally employed, approximations and engineering judgment was used because of the planning level nature of this exercise and the unpredictability of specific cost items.

APPENDIX D

ARROYO SCOPE OF WORK

SCOPE OF WORK FOR ENVIRONMENTAL SERVICES

Objective:

In support of an effort to lower ground elevations within the current Lake Cypress Springs emergency spillway Arroyo Environmental Consultants, LLC is proud to present this Scope of Work for Environmental Services. This Scope outlines work required to complete a wetland delineation and a stream Ordinary High Water Mark (OHWM) determination following United States Army Corps of Engineers (USACE) methodologies. Work will be summarized in a wetland delineation report and all data will be provided in the Client's preferred format.

Tasks:

Work associated with Tasks 1 and 2 will focus on the identification of jurisdictional water bodies with the assumption that future project activities will avoid these jurisdictional areas, therefore negating the need for a USACE Section 404 Permit. Work will follow USACE methodologies and meet Section 404 permitting requirements in the event Task 3 is authorized by the client.

Task 1 – Wetland delineation

This task will include a wetland delineation of the current Lake Cypress Springs emergency spillway area. Work will include delineation of the lake shoreline and any riverine forested wetlands associated with Andys Creek. Wetland boundaries will be surveyed utilizing Trimble survey grade GPS units.

Task 2 – OHWM determination

Andys Creek OHWM will be identified following USACE protocols and marked for future construction activities. Creek boundaries will be surveyed utilizing Trimble survey grade GPS units along the width of the existing emergency spillway.

Task 3 (Optional) – USACE Section 404 Permit

Work will include the preparation, submittal and successful issuance of a USACE Section 404 Permit. Work activities are assumed to meet the requirements for a Nationwide Section 404 Permit 31 – Maintenance of Existing Flood Control Facilities.

*All construction activities which cannot avoid jurisdictional areas such as lake shoreline wetland vegetation or areas below Andys Creek OHWM, will require a USACE Section 404 Permit.**

If a Section 404 Permit is needed, additional environmental studies will be required. This work could include threatened and endangered species critical habitat reviews, a stream assessment, hydrology modeling of Andys Creek, cultural resource studies and permit coordination.

Timeline and Budget:

Costs include travel, logistics and equipment rental. All work will be billed on a time and material basis.

Task 1- Wetland delineation costs are estimated at $17,000

Task 2 - OHWM determination costs are estimated at $5,500

Task 3 (optional) – Costs are not provided in this Scope of Work, but are documented in detail in Arroyo (2016)[1] which was submitted to Carollo Engineers, Inc and Franklin County Water District.

[1] Arroyo Environmental Consultants, LLC. 2016. Environmental Evaluation of Two Proposed Infrastructure Modifications to Lake Cypress Springs.

APPENDIX E

EXTRACTED PAGES FROM DAM OPERATIONS MANUAL

Photo 12: Aerial view of the emergency spillway.

5.1 EMERGENCY SPILLWAY OPERATIONS

Flows through the spillway are uncontrolled. The spillway engages when the lake level exceeds 385 feet-msl. Flows from the spillway discharge across County Road 3122 and around the end of the dam, into a small creek and then downstream into Lake Bob Sandlin. The rating curve for the emergency spillway is provided in Table 2.

5.2 EMERGENCY SPILLWAY MAINTENANCE

Maintenance of the spillway should include the activities described in the following sections.

5.2.1 Debris/Obstruction Removal

The emergency spillway should be kept clear of all obstructions, including thick brush, small trees, large rocks or boulders, and any other debris that may reduce the spillway capacity.

5.2.2 Mowing

Occasional mowing of the emergency spillway will be necessary. A short grass cover provides an ideal surface to protect against erosion, prevents harborage for burrowing animals, and also allows for easier detection of incipient problems.

5.2.3 Small Tree and Brush Removal

Any woody vegetation or other brushy vegetation growing on the grass-protected portions of the emergency spillway should be removed. The vegetation may be removed by trimming flush with the ground.

5.3 INSPECTION OF EMERGENCY SPILLWAY

The spillway should be visually inspected monthly and after any event where the spillway was engaged. The inspection should include checking for erosion or loss of grass protection, as well as the presence of any obstruction in the spillway including thick brush, and small trees.

The Emergency Spillway Inspection Table in Appendix C contains a list of potential observations that may be seen during an inspection of the emergency spillway, as well as recommended follow-up actions for each. Appendix D contains a Spillway Inspection Checklist.

6.0 INSTRUMENTATION

The installed instrumentation consists of piezometers. Piezometers are used to monitor piezometric pressures in the dam and foundation to permit the long-term monitoring of the dam.

6.1 PIEZOMETERS

Piezometers were installed during 1981 to monitor hydrostatic uplift while conducting a slope stability analysis. Most of those piezometers cannot be found or cannot be accessed to obtain water level readings. Information regarding piezometers installed in 2011 can be found in Appendix G.